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**NOTICES**

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# THE EFFECT OF SHORT PERIODS OF UNDERNUTRITION AFTER CALVING ON THE ESTABLISHMENT OF LACTATION IN DAIRY COWS

By D. S. FLUX and M. R. PATCHELL, The Dairy Research Institute (N.Z.), Palmerston North

(*Received for publication, 27 February 1957*)

## Summary

The effect on the initiation of lactation of underfeeding monozygous twin cows for five or ten days immediately after calving was investigated.

Underfeeding for five days had little or no effect.

Underfeeding for ten days caused maximum daily milk yields to be lowered, the difference being statistically significant only at the 10% level. Maximum daily milk yields were reached earlier in the cows underfed for ten days than in the controls or cows underfed for five days (difference highly significant). The solids-not-fat percentage of the milk of the cows underfed for ten days was depressed in early lactation, the constituent mainly affected probably being lactose. Butterfat percentage was increased. These differences disappeared soon after normal feeding started.

The effects of underfeeding for ten days on the composition of milk given during the first three weeks of lactation were similar to those in previous studies, namely a rise in butterfat percentage and a fall in the percentage of solids-not-fat.

## INTRODUCTION

The effect of underfeeding dairy cattle in the period immediately after calving has previously been investigated at this Institute by Flux and Patchell (1954) and by Patchell (1957). The main object of these studies was to observe the changes in the levels of the major milk constituents during the underfeeding period and the time taken for them to return to normal when full feeding was resumed. In the first experiment the underfeeding started two weeks after calving and lasted for six weeks. In the second, the duration of the period of underfeeding for the cows in one group was also six weeks, but it was started immediately after calving. In both cases the yield of milk was depressed and the percentages of solids-not-fat and total protein were reduced during the underfeeding period. In the first experiment butterfat percentage was

increased by the underfeeding, in the second, no satisfactory data on butterfat percentages were obtained.

Because it was possible that undernutrition in the first few days following calving might interfere with the initiation and establishment of full lactation a further experiment was planned. Cows were underfed for short periods starting immediately they had calved, and the differences in the time taken to reach maximum daily yields of milk, the difference in the maximum daily yields, and differences in milk composition were observed.

## MATERIALS AND METHODS

Fifteen pairs of monozygous twin cows were used in an incomplete balanced block experiment with three treatments. Details of the animals are in Table 1.

TABLE 1. DETAILS OF MONOZYGOUS TWIN COWS

| Cow No. | Age (years) | Breed | Days Between Calving Dates |
|---|---|---|---|
| T9-10 | 2 | Grade Jersey | 0 |
| T35-36 | 2 | ,, ,, | 69 |
| T23-24 | 2 | ,, ,, | 5 |
| T51-52 | 2 | ,, ,, | 47 |
| T55-56 | 2 | ,, ,, | 8 |
| T11-12 | 3 | ,, ,, | 19 |
| T27-28 | 3 | Friesian | 7 |
| T39-40 | 3 | Jersey × (Friesian × Ayrshire) | 14 |
| T13-14 | 4 | Jersey × Friesian | 18 |
| T85-86 | 4 | Grade Jersey | 2 |
| T93-94 | 4 | ,, ,, | 0 |
| T43-44 | 5 | ,, ,, | 5 |
| T49-50 | 6 | ,, ,, | 1 |
| T89-90 | 6 | ,, ,, | 3 |
| T17-18 | 8 | Jersey × (Jersey × Polled Angus) | 11 |

*Milk Sampling.* The milk from each cow was weighed at each milking and every week two-day composite milk samples were taken for determination of butterfat content (Gerber method), total solids (gravimetric method) and total protein (Kjeldahl method).

*Feeding and Management.* Before lactation all cows were fed normally on pasture, supplemented with a generous allowance of grass silage and hay. All were in reasonable condition at calving.

Treatment A: Cows in treatment group A were fed ample autumn-saved pasture plus a little silage from calving onwards.

Treatment B: Cows in treatment group B were placed, immediately they had calved, in a small area bared of pasture, and given ten pounds of average quality hay per cow per day as the only food. After five days they were returned to normal feeding with the cows of Group A.

Treatment C: Cows in treatment group C were treated in the same way as those in Group B except that underfeeding lasted for ten days.

Each cow was weighed at calving and thereafter once each week on a scale accurate to within one pound.

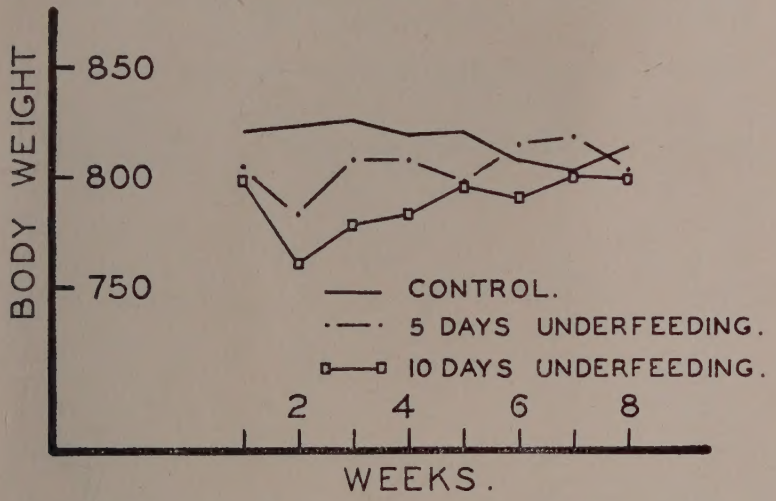


Fig. 1.—Mean body weights of cows in the groups underfed for 5 or 10 days, and of those in the control group, for the first eight weeks after calving.

## RESULTS

*Body Weight.* The average weight changes from calving until the eighth week of lactation for cows in each group are shown in Fig. 1. By the eighth week the average body weights were very similar and they did not differ appreciably throughout the remainder of the lactation.

The average body weights for the cows in each group and the group comparisons at 14, 21, and 56 days are shown in Table 2.

TABLE 2. AVERAGE BODY WEIGHTS AT 14, 21, AND 56 DAYS AFTER CALVING

| Group | A | B | C | A-B | A-C | B-C |
|---|---|---|---|---|---|---|
| 14 days | 823 | 783 | 759 | 40 | 64 | 24 |
| 21 days | 824 | 807 | 777 | 17 | 47 | 30 |
| 56 days | 813 | 803 | 798 | 10 | 15 | 5 |

By the fourteenth day of lactation the cows in Group B and C had time to make up any difference between the food contents of their alimentary tracts and those of the cows in group A. It is apparent that the cows that were underfed were lighter than the control animals (group A) in the first few weeks after underfeeding and that these differences were very small by the eighth week of lactation. The cows that were underfed for ten days lost more body weight than those underfed for five days.

*Production.* The group means for milk yield, butterfat yield, and percentages of butter fat, solids-not-fat and total protein, for the first three weeks of lactation are shown in Table 3. The means have been adjusted for block effects (Cochran and Cox 1950).

TABLE 3. ADJUSTED TREATMENT MEANS AND COMPARISONS FOR THE FIRST 21 DAYS OF LACTATION

| Treatment & Comparisons | Milk Yield (lb.) | Butterfat (lb.) | Butterfat (%) | S.N.F. (%) | Total Protein (%) |
|---|---|---|---|---|---|
| A | 546.9 | 27.8 | 5.14 | 9.45 | 3.78 |
| B | 486.5 | 23.6 | 4.88 | 9.49 | 3.91 |
| C | 370.6 | 21.2 | 5.76 | 9.09 | 3.74 |
| A-B | 60.4 | 4.2(*) | 0.26 | −0.04 | −0.13 |
| A-C | 176.3** | 6.6* | −0.62* | 0.36** | 0.04 |
| B-C | 115.9* | 2.4 | −0.88** | 0.40** | 0.17 |

Significant at (*)10%, *5%, **1%

The differences between the means for the control cows in group A and those underfed for 5 days in group B were small and not significant at the 5% level. Those between the means for the control cows and for the cows in group C were larger and, except in the case of total-protein percentage, were significant or highly significant. Milk and butterfat yields and the solids-not-fat content of the milk were depressed, while the butterfat content was increased by underfeeding for 10 days.

An indication of the time taken for milk composition to return to normal after underfeeding ceased is given by the comparisons between the adjusted means in Table 4.

TABLE 4. ADJUSTED MEAN PERCENTAGES OF BUTTERFAT AND SOLIDS-NOT-FAT FOR THE PERIODS 4–6 AND 6–8 WEEKS AFTER CALVING

| Treatment | 4–6 Weeks | | 6–8 Weeks | |
|---|---|---|---|---|
| | B.F.% | S.N.F.% | B.F.% | S.N.F.% |
| A | 5.07 | 9.25 | 4.81 | 9.20 |
| B | 4.77 | 9.10 | 4.60 | 9.21 |
| C | 4.81 | 9.06 | 4.71 | 9.19 |

None of the differences between means were significant.

The differences in butterfat percentage of the milks of the cows in the different groups were reduced (and not significant) by 4–6 weeks, and were still smaller by 6–8 weeks. The differences in solids-not-fat percentage were also small at 4–6 weeks and had disappeared by 6–8 weeks.

The effects of the treatments on maximum daily milk yields and the times taken to reach maximum yields are shown in Table 5. Maximum daily yields were measured by taking the average of the three highest consecutive daily yields for each cow.

TABLE 5. DAILY MILK YIELDS AND TIMES TAKEN TO REACH MAXIMUM YIELDS

| Treatments and Comparisons | Maximum Daily Milk Yield (lb.) | Time Taken To Reach Maximum Daily Milk Yield (days) |
|---|---|---|
| A | 33.5 | 64 |
| B | 34.6 | 57 |
| C | 29.2 | 41 |
| A–B | 1.1 | 7 |
| A–C | 4.3(*) | 23** |
| B–C | 5.4(*) | 16* |

Although the peak daily milk yield for the cows underfed for ten days was lower than for the cows in the other two groups the differences were not significant. The differences between the means for the cows in groups A and B was very small and also not significant.

The treatments appeared to affect the time taken to reach maximum milk yields. The cows underfed for ten days reached their peak 23 days earlier than the controls in group A, and 16 days earlier than those in group B. These differences were significant, but although the cows in group B reached their peak 7 days before the control cows this difference did not reach the 5% level of significance.

Because butterfat yields were not determined each day, and the butterfat yield curves were very flat, it was not possible to find the times taken to reach maximum daily butterfat yields as precisely as those for maximum milk yields. The estimates obtained yielded the following averages for number of days from calving to maximum daily butterfat yields: treatment A, 60; treatment B, 69; treatment C, 63. The differences between these were not significant.

## DISCUSSION

Although underfeeding for 10 if not for 5 days undoubtedly affected the body weights, milk yields, and milk composition of the cows in the first few weeks of lactation, there was no very definite evidence of an effect on maximum daily milk yields. It is possible that the differences of 5.8 lb. and 4.3 lb. between the mean for the cows in group C and for those in groups A and B respectively did represent a real depression caused by underfeeding for 10 days, but as the differences were statistically significant at the 10% level only, no definite conclusion can be drawn from the data. However, the time taken for the peak daily yield to be reached was reduced by underfeeding for ten days. The reason for this is not known.

Initiation of lactation did not appear to be affected appreciably by the underfeeding, the cows in all groups giving a good flow of milk in the first few days after calving. The depression in milk yield and solids-not-fat content of the milk of the cows underfed for ten days appears to have been due mainly to the continued underfeeding, as those underfed for five days showed only small differences from the control cows.

The increase in the butterfat content of the milk of the cows in group C during the first three weeks of lactation (0.88% when compared with that of the controls and 0.62% when compared with that for group B) is notable. In a previous experiment where underfeeding was continued for six weeks but started two weeks after calving, a difference of 0.5% was found (Flux and Patchell 1954). It is probable that, as in the earlier experiment, the rise in butterfat percentage was associated with the use of body-tissue reserves by the cows. As shown by the composition of the milk in the period 4 to 6 weeks after calving, the difference in butterfat content disappeared soon after normal feeding was resumed. It was, in fact, approximately the same as that of the control cows' milk fourteen days after calving.

The depression in the solids-not-fat content of the milk of the cows underfed for ten days was of the same order as that observed by Flux and Patchell (1954) and Patchell (1957) in their previous studies of the effects of underfeeding after calving. As was the case with butterfat percentage, the effect disappeared soon after normal feeding was resumed.

As far as the effects on milk composition were concerned, the results of the present experiments are in general agreement with those of other workers cited by Flux and Patchell (1954) and of Lauri Palcheimo, Eine Herkoler, and Aarne Makala (1955). The latter found that the cows recovered slowly from the effects of underfeeding for three days, a contrast with the present experiment which is probably explained by the fact that in their study the underfeeding occurred later in lactation.

From the changes in milk composition it can be seen that the effects of underfeeding for the five days immediately after calving on the yield of milk products was negligible. However, if the underfeeding was continued for a few days longer the normal changes associated with underfeeding, namely a fall in solids-not-fat and a rise in butterfat percentage, were evident for the first three weeks of lactation.

To the dairy husbandman it was of interest that a fairly severe but short period of underfeeding following calving did not affect the initiation of lactation, or, apparently, the performance during the subsequent lactation to any great extent. But continuation of underfeeding to ten days after calving, apart from the immediate effects on milk yield and composition, did change the time at which maximum yields were reached, and there was a suggestion that maximum daily yield of milk was lowered.

Because some of the cows were used for other experiments later in lactation, it was not possible to estimate the effects of the treatments on whole-lactation yields of milk and butterfat.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. F. H. McDowall in whose laboratory all milk analyses were done, to Mr. D. C. Collis for technical assistance, and to the farm staff under Mr. A. H. Goodman for care of experimental animals. They are indebted also to Professor W. Riddet for his interest in presenting the results.

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# THE ABILITY OF COWS AND CALVES TO DIGEST GRASS

By A. T. G. McARTHUR, Ruakura Animal Research Station, Department of Agriculture, Hamilton*

*(Received for publication, 18 February 1957)*

## Summary

Three cows and three 8–10 week calves were used in a digestibility experiment to compare their ability to digest high quality grass. The dry matter digestibility coefficients for the cows and the calves were 75.2% and 74.6% respectively.

## INTRODUCTION

There is little doubt that at birth the calf is unable to digest fibrous foods such as grass, and it is generally assumed that throughout the calf stage (up to six months of age) the calf is unable to digest pasture as efficiently as adult cattle. This opinion, which is sometimes expressed in practical text books on dairy husbandry, is used to explain why calves require milk, but lacks experimental evidence for its support. In fact, a certain amount of indirect evidence to the contrary has appeared in the literature. Percival (1951) successfully weaned calves at eight weeks of age by rotationally grazing them on high-quality pasture. Conrad *et al.* (1950) found that nine-week-old calves digested 72% of the dry matter of lawn clippings, and later Armstrong, Preston, and Armstrong (1954) found that calves aged between ten and twelve weeks digested 75% of the dry matter of spring grass in the pre-flowering stage.

In 1951, the author (unpubl.) attempted to measure the ability of calves to digest cellulose by inserting household cotton (a pure form of cellulose) into the rumen of fistulated calves—a technique developed by Balch and Johnson (1951). Fistulas were inserted into six calves at two and three weeks of age. Two animals grew normally and rumen disintegration of cotton was observed in these animals from three weeks of age onwards. One calf which was fistulated at two weeks of age failed to thrive, but cotton inserted immediately after the operation was performed had almost entirely disintegrated after 48 hours in the rumen. Observations by the author on the grazing behaviour of calves showed that the majority start ruminating at about ten days after birth. These results suggest that calf rumen function might start at an earlier age than is commonly accepted. Consequently, in 1952, an experiment was designed to compare the digestibility coefficient of good-quality pasture fed to three eight-week-old calves and three adult cows.

## EXPERIMENTAL

Three grade Jersey heifer calves were selected from a group of 50 calves. These three animals, numbers 57, 58, and 70, were approximately the same weight and were all born on the same day. Selection was made at five weeks of age. They averaged 120 lb. when eight weeks old and reached this age one day before the trial commenced. They had had free access to pasture from birth and had been fed whole

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milk twice daily at a level of 15% of their liveweight until five weeks of age. The three adult cows, numbers 114, 192, and 222, were grade Jerseys that had been used in digestibility trials and were known to maintain a constant good intake under trial conditions. These animals were dry.

*Pre-Period*

To accustom the calves to eating cut grass, the three calves were taken off pasture three weeks before the trial was due to start and housed in a shed which was divided into three pens each with a feeding box.

The whole-milk feeding was as follows:

| | |
|---|---|
| 5–6 weeks | 6 pints per day |
| 6–7 weeks | 4 pints per day |
| 7–7½ weeks | 2 pints per day |

Between the fifth and seventh week, cut grass was fed *ad lib.* but, during the week before the commencement of the trial, the intake was limited to 1 kg. of dry matter daily. This was the level of intake found from the previous period that would be likely to be maintained with minimum residues.

The cows also had a three-week pre-period. For the first week they were stall-fed *ad lib.* on cut grass. After feeding they were muzzled and turned out to pasture. For the second and third weeks, the amount of grass was restricted to 5 kg. per day in the case of 114 and 4 kg. per day for 192 and 222. The animals were kept in the stalls or yards all day and put out muzzled into a paddock at night.

*Duration of Trial*

Starting on 17 November 1952, a 15-day trial was carried out. The collection of the dung commenced 24 hours after the first feed of the trial proper had been offered to the animals.

*Feed*

Throughout the pre-period and trial period, young spring grass, cut from a permanent pasture of ryegrass, cocksfoot, paspalum, and white clover, was used. The pasture had been topped prior to the commencement of the trial to ensure evenness in the material to be fed. The animals were fed twice daily (10 a.m. and 4 p.m.). For each feed a fresh load of grass was cut and brought to the nutrition shed. The feeding procedure was designed to ensure a constant daily intake of dry matter by each animal. A sample of fresh grass was taken from the load and placed in a cylinder through which air at 110°c. was blown for 30 minutes, a rough dry-matter percentage being calculated by this method. The wet weight of each animal's ration was calculated from this figure, so that it was possible to maintain the dry-matter intake of each animal at an even level.

As a ration was being weighed into each animal's feed box, small handfuls of grass were thrown into a small heap. From each heap about a 200 g. sample was weighed into a tared cloth bag, dried for 24 hours in an air drier at 70°C. and for a further 24 hours in an oven at 110°C. From these samples, nine dry-matter determinations were made which could be related to each feed.

A 100 g. representative sample of fresh pasture was taken from each feed for analysis of chemical composition. These samples were dried and bulked.

Residues remaining when the afternoon ration was given were mixed with the ration. Residues remaining in the morning were weighed. If less than ½ kg. for the cows or 200 g. for calves, the weight was subtracted from the total green weight offered during the preceding 24 hours, but if greater, two 200 g. samples were taken for dry-matter analysis, and the correction of dry-matter intakes for residues was made at the dry-matter stage of the calculations.

*Faeces*

Faeces were collected manually. Throughout the 15-day trial two people were stationed behind the animal with catching containers for collecting the faeces. It was found that stimulation of the animals to elicit the defaecation reflex by palpating the anus simplified the process of collection. After an animal had urinated, the floor was washed down with water so that, should some faeces be missed, it was possible to recover it without contamination. However, very little was in fact missed. This system of collection, although expensive, is extremely reliable.

After each defaecation, the faeces plus the container were weighed, double checked by each person, and recorded. The tare weight of the container was painted on each and was substracted from the total weight. Each defaecation was scraped out of the catching containers into a garbage tin with a well-fitting lid. These tins were sampled for dry matter and faeces analysis at 8 a.m. each day. Approximately 1 kg. of the wet faeces from each animal was put into a bucket after stirring the total daily output thoroughly in the garbage tin. This sample was thoroughly mixed by squeezing it through gloved fingers for five minutes, great care being taken to break down any lumps. Two sub-samples for dry matter analysis were dried for 48 hours at 110°C. Aliquot samples for chemical analysis were taken from the dry sample after the daily output of faeces dry matter had been calculated. The feed and the faeces were analysed for ash, nitrogen, ether extract, and crude fibre.

## RESULTS AND DISCUSSION

During the 15-day trial, the dry-matter intake of each animal remained fairly constant from day to day, and there were few feed residues. The digestibility coefficients for crude protein, crude fibre, ether extract, ash, and nitrogen-free extract, as well as organic matter and dry matter, are shown in Table 1.

From the analysis of the grass used in the trial, it was clear that it was of high quality, having a crude-protein content of 24.7%. The digestibility coefficient for dry matter for cows and calves was 75.2% and 74.6% respectively, showing that there is no difference between

TABLE 1. Digestibility Coefficients for Cows and Calves

| | % of D.M. | Cow 114 | Cow 192 | Cow 222 | All Cows | Calf 57 | Calf 58 | Calf 70 | All Calves |
|---|---|---|---|---|---|---|---|---|---|
| Dry matter | — | 76.2 | 73.1 | 75.8 | 75.2 | 75.2 | 75.0 | 73.5 | 74.6 |
| Organic matter | 88.2 | 80.9 | 78.6 | 81.4 | 80.4 | 77.5 | 78.0 | 77.0 | 77.5 |
| Crude protein | 24.7 | 79.7 | 78.9 | 80.7 | 79.8 | 72.6 | 73.2 | 72.6 | 72.8 |
| Crude fibre | 18.8 | 80.7 | 77.1 | 81.4 | 79.8 | 79.6 | 79.8 | 79.8 | 79.7 |
| Ether extract | 5.4 | 66.4 | 63.7 | 66.5 | 65.6 | 64.5 | 64.1 | 68.5 | 65.6 |
| Ash | 11.8 | 40.9 | 32.2 | 34.0 | 36.2 | 57.9 | 52.6 | 47.0 | 52.6 |
| N-free extract | 39.4 | 83.8 | 81.3 | 83.9 | 83.1 | 81.3 | 82.1 | 79.7 | 81.1 |

the ability of cows and 8–10-week-old calves to digest grass of this quality. The digestibility coefficients for crude fibre for calves and cows was 79.7% and 79.8% respectively. The coefficient for the ether extract was the same.

The digestibility of the ash was higher for the calves (52.6%) than for the cows (36.2%) suggesting that the retention of minerals is high in the calf stage when skeletal development is rapid. On the other hand, the coefficient for the crude protein was slightly lower for calves (72.8%) than for cows (79.8%). A low figure for crude-protein digestibility in an experiment with calves has also been reported by Armstrong, Preston, and Armstrong (1954). This may be due to a lower true-protein digestibility for calves or a faster rate of secretion of metabolic protein. Blaxter and Wood (1951) have demonstrated the high secretion of metabolic nitrogen in very young calves, so that this is probably the cause of the difference between the cows and the calves in the digestibility coefficients calculated from this trial.

The results of this experiment disagree with the widely held concept that calves are unable to utilize grass—a concept that has been based on deductions from anatomical studies of alimentary-tract development and not on actual digestibility trials.

The experiment was conducted with high-quality grass only. We do not know whether the calves would be as efficient at digesting poor-quality grass as adult cows; nor do we know whether even younger animals can digest young grass as efficiently as cows. However, from observations on cellulose disintegration, it appears that rumen functions begin at a very early age.

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# THE INOCULATION OF CALVES WITH CUD MATERIAL FROM ADULT COWS

By A. T. G. McArthur, Ruakura Animal Research Station, Department of Agriculture, Hamilton*

*(Received for publication, 18 February 1957)*

**Summary**

The inoculation of free-grazing calves with cud material from adult cows did not significantly affect growth rate.

## Introduction

Percival (1951) at this Research Station has shown that calves can be weaned successfully at eight weeks of age when rotationally grazed on high-quality spring pasture. However, calves weaned at eight weeks have shown a small post-weaning check. Pounden and Hibbs (1949) have suggested that calves reared out on pasture may be somewhat limited in their ability to utilize pasture if certain rumen micro-organisms are lacking, and have recommended the inoculation of young calves with cud material from adult cows. The absence of certain rumen micro-organisms could possibly account for the check in growth rate observed by Percival, and so an experiment was designed to compare the growth rates of early weaned calves inoculated with cud material from adult cows with a control group to see whether inoculated calves had a faster growth rate after weaning.

## Experimental

From a spring-calving 100-cow herd, 26 heifers were selected on the basis of being born within 14 days. These were divided into two random groups. One group was inoculated during the second and third weeks of life with rumen micro-organisms from adult cows, using cud material. Each cud taken from cows grazing comparable quality grass was used to inoculate three calves. The cud material was administered orally. The other group of 13 calves was left as controls. One member of this group was removed from the farm a few days after birth, leaving 12 controls.

The calves were grazed on dairy-farm pastures from birth onwards and high-quality spring grass was made available to them by a system of rotational grazing whereby calves were put in a fresh paddock of grass every two or three days. Both groups of calves were run together.

The calves of both groups were fed whole milk at a daily rate of 15% of the liveweight. The daily milk ration was fed in two meals. From six to eight weeks, the whole-milk ration was progressively reduced and all animals were weaned at eight weeks. Calves were weighed weekly and health records were kept.

## Results and Discussion

The birth weights andweights at four, eight, and twelve weeks of age are shown in Table 1.

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TABLE 1. Weights of Inoculated and Control Calves

| Inoculated | | | | | Control | | | | |
|---|---|---|---|---|---|---|---|---|---|
| No. | Birth Weight | Weight at age of 4 weeks | 8 | 12 | No. | Birth Weight | Weight at age of 4 weeks | 8 | 12 |
| 88 | 37 | 81 | 122 | 148 | 36 | 54 | 89 | 127 | 150 |
| 39 | 55 | 100 | 131 | 161 | 38 | 51 | 85 | 129 | 151 |
| 42 | 56 | 99 | 128 | 154 | 40 | 53 | 108 | 129 | 170 |
| 44 | 55 | 89 | 130 | 153 | 77 | 42 | 81 | 116 | 147 |
| 49 | 41 | 80 | 124 | 142 | 48 | 57 | 94 | 142 | 168 |
| 47 | 54 | 92 | 121 | 160 | 46 | 51 | 88 | 132 | 170 |
| 52 | 56 | 87 | 125 | 165 | 53 | 57 | 96 | 124 | 141 |
| 59 | 54 | 87 | 133 | 175 | 55 | 52 | 88 | 132 | 157 |
| 61 | 63 | 91 | 141 | 186 | 58 | 51 | 94 | 134 | 162 |
| 63 | 47 | 81 | 129 | 154 | 67 | 49 | 88 | 137 | 159 |
| 70 | 58 | 100 | 138 | 167 | 75 | 60 | 94 | 130 | 144 |
| 82 | 57 | 90 | 124 | 154 | | | | | |
| Av. | 52.6 | 91.0 | 129.9 | 161.3 | | 52.7 | 91.4 | 131.6 | 156.5 |

There was no appreciable difference in weights at four or eight weeks. The inoculated group were 4.8 lb. heavier than the controls at twelve weeks of age. During the month after weaning (between eight and twelve weeks), the inoculated group gained 31.4 lb. while the control group gained 24.9 lb.—a difference of 6.5 lb. in growth rate in favour of the inoculated group. However, this difference was not statistically significant nor was the difference in weight between groups at twelve weeks. In this experiment, therefore, inoculation did not significantly increase the growth rate of calves after weaning (between eight and twelve weeks).

It has been suggested that rumen function in calves starts as early as two or three weeks after birth under New Zealand conditions where calves are reared out on pasture from birth onwards (McArthur, 1957). Further experiment has shown that eight- to ten-week-old weaned calves were as efficient at digesting high quality grass as adult cows. This means that the necessary micro-organism for efficient rumen function with this type of grass must be present at eight weeks. It is, therefore, not surprising that the artificial inoculation of calves with rumen microflora produced no significant difference in growth rate in this experiment with early-weaned calves.

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# THE BREEDING OF PEAS RESISTANT TO *Fusarium* WILT

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(*Received for publication, 7 January 1957*)

**Summary**

The breeding and selection of wilt-resistant lines of three varieties of garden peas and two varieties of field peas are described.

## INTRODUCTION

Pea wilt (*Fusarium orthoceras* Appel. et Wollenw. var. *pisi* Linford) was first recorded in New Zealand by Cruickshank (1951a). Surveys of pea crops in Canterbury, Auckland, and Marlborough (Cruickshank, 1951b) have shown that wilt annually causes severe losses to growers. The only effective means of control is through the use of resistant varieties (Walker 1952). Many resistant varieties have been listed, (Walker, 1931: Wade 1938) and more have been bred in the United States. The use of these in New Zealand has been restricted because the pea-seed industry is founded on the exportation of certain commercially marketable varieties viz. *Garden Peas*: Greenfeast, (syn. Lincoln), William Massey (syn. Kelvedon Wonder), Onward; *Field Peas*: Partridge (syn. N.Z. Maple) and Blue Prussian, (syn. Lincoln Small Blue). These are wilt-susceptible varieties.

A breeding programme was undertaken to incorporate wilt resistance into the above varieties, and the results are reported here.

## MATERIALS AND METHODS

The backcross method was used because wilt resistance is inherited as a single dominant gene (Wade, 1929), and suitable recurrent parents were available.

The parents used in the programme were:

| Cross No. | Recurrent Parent (susceptible) | Non-recurrent Parent (resistant) |
|---|---|---|
| 1/1 | Onward | Delwiche Commando |
| 1/13 | Onward | Morse's Market |
| 1/7 | Onward | Senator |
| 2/2 | Greenfeast | Senator |
| 3/8 | William Massey | Senator |
| 3/14 | William Massey | Delwiche Commando |
| 4/12 | Blue Prussian | Delwiche Commando |
| 5/4 | Partridge | Marathon |
| 5/11 | Partridge | Delwiche Commando |

An attempt to reduce the number of backcrosses was made by matching recurrent and non-recurrent parents as closely as possible,

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and by selecting resistant plants in each generation for likeness to the recurrent parent. Selfing for selection was first carried out after the fourth backcross, but back-crossing was continued to the eighth generation. The inherent diversity of the recurrent parent variety was preserved as far as possible by using random plants of the variety in crossing.

Concurrently with the breeding programme, varieties of commercial origin were grown in heavily wilt-infected nursery plots and single-plant selections were made for wilt resistance.

Disease reactions of material from both selection and backcrossing were obtained in two ways viz. glasshouse tests in artificially inoculated soil and field tests in naturally infected plots where infection had been built up by frequent planting of peas to such a degree that wilt developed in all plants of susceptible varieties sown.

Agronomic and botanical characteristics, viz. yield, seed type, pod type, flowering time, and maturity time, were measured and compared with the susceptible parent varieties.

Samples of the resistant selections are being sent to the National Institute of Agricultural Botany, Cambridge, England, for varietal type testing under English conditions, as homozygous lines of the varieties become available.

## RESULTS

### *Backcrossing*

In the crosses where both parents were of similar type, backcross progenies were very similar to the recurrent parent after only one backcross, e.g. Crosses 1/1; 1/13.

Where parents of different type were used, considerable variation in type was evident in the first four backcrosses. In the wider crosses, e.g. 5/11, 3/8, the material was reduced by selection of the recurrent parent type up to the fourth backcrossing.

Selections from selfing after backcrossing were tested for wilt reaction for two successive generations, and homozygous resistant lines were increased for yield trial and checking of agronomic and botanical characters before lines were bulked for final trial. No single-plant lines were included in this bulking unless they conformed to the corresponding variety in all respects and have been shown in trials to approximate the variety in yield.

Material from 5th to 8th backcrosses has been reserved.

### *Pure-line Selection*

Single-plant selection for wilt resistance in the variety Onward from field plots failed to produce any resistant lines, and highly susceptible progenies suggested that apparent resistance in selected plants was due to accidental "escapes" from disease, rather than a measure of inherited resistance. William Massey and Partridge were entirely susceptible in field tests and thus did not produce any progenies for testing.

Ninety-seven wilt-resistant single-plant selections were made from a plot of Greenfeast of commercial origin. Sixty-four of these produced

lines showing high resistance in glasshouse tests. Many of these however, were discarded as varietal impurities and, among the remainder, selections for flowering and maturity dates comparable with standard Greenfeast reduced the number to five. Trials of these lines have shown that they yielded as well as the susceptible Greenfeast variety (Yen and Cruickshank, 1957). Samples tested in England have been reported on favourably, having shown high resistance to the strain of wilt occurring there.

In Blue Prussian, sixty selections produced lines with high resistance to wilt. However, the range of variation from accepted varietal type of many characters in these plants made selection of resistant lines slower.

*Lines for Release*

Wilt-resistant Greenfeast derived from pure-line selections of the variety have already been released to the seed trade.

Resistant lines of the following varieties are in yield trial stages and will be released within the next five years.

| Wilt-resistant Lines | Parentage |
|---|---|
| Greenfeast | Pure-line selections from Greenfeast |
| William Massey | Selections after backcrossing (Cross 3/8) |
| Onward | „ „ „ (Cross 1/1) |
| Partridge | „ „ „ (Cross 5/4) |
| Blue Prussian | Pure-line selections from Blue Prussian. |

## DISCUSSION

Wilt-resistant lines of New Zealand standard varieties of garden and field peas are being developed by pure-line selection and backcrossing. These resistant lines are indistinguishable, in all main agronomic characters including yield, from the wilt-susceptible varieties which they are intended to replace. The release of these varieties should enable peas to be grown successfully, and normal crop rotation pursued, in many areas where at present serious losses are common.

Pea wilt has been reported as a limiting factor in pea-growing in England (Buxton and Storey, 1954) to whose markets much of New Zealand's pea seed is exported. The inclusion of the resistance character in exported varieties should therefore be of some importance in the maintenance of demand for New Zealand seed.

## ACKNOWLEDGEMENTS

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# SLAUGHTER WEIGHT OF BEEF CATTLE FOR THEORETICAL MAXIMUM ENERGETIC EFFICIENCY

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(*Received for publication, 6 March 1957*)

**Summary**

Theoretical studies of the energy cost of beef production suggest that while the calory cost per pound of body weight varies markedly with live-weight gains and calving percentages, the point of diminishing returns ranges from only 850 to 1,100 lb. live weight. In most cases, the level is 900 to 950 lb.

Accordingly, there appears to be justification for killing New Zealand beef animals at a much lighter weight than is common at present.

While, at present, energetic efficiency is not the single over-riding factor in beef-cattle production, current exponential growth rates of human populations suggest that it will be, if animal-protein requirements are to be met in this form. Predictions that beef "broilers" will be the next step in the beef industry, to make maximum use of feedstuffs in the same way that the poultry industry has introduced its new marketing trends, have been heard from many authorities in Canada, the United States, and Great Britain. For example, Wood[1] recently reported that under present marketing conditions an animal weighing 800 lb. live weight may be sold in Canada at a greater profit than one which attains the usual marketing minimum of 1,000 lb. However, the maintenance, pregnancy, and lactation costs of the dam must be included if the true optimum selling weight of carcass animals is to be established. By employing current standards and some assumptions suggestive of somewhat utopian management, the point of energetic diminishing returns may be estimated. Utilizing Brody's[2] standards for maintenance and pregnancy and the energetic requirements for growth reported by Sylvestre and Williams[3], as well as assumptions of an average birth weight of 70 lb.[4], a milking efficiency of 25%[5, 6], and ages at separation from the dam of 0, 120, and 180 days, caloric costs per pound of live weight have been calculated for cattle growing at differential daily rates. Assumed daily rates of gain were 1 or 2 lb. per day from birth to 400 lb. and 1½ or 2 lb. per day over 400 lb. liveweight[6]. Dams were assumed to maintain a constant bodyweight of either 800 or 1,000 lb., except during pregnancy. Caloric costs were also calculated for calving percentages of 100 and 75. The 1,000 lb. cow weight and 75% calving approximate current New Zealand averages[7, 8]. In all cases, efficiency of gain over maintenance was considered equal at equal body weights for the treatments illustrated.

The results have been graphically illustrated in two ways. The upper graph (Fig. 1) represents a calving percentage of 100, while the lower represents a feeding standard for pregnancy with a 75% calf crop realized. It may be seen that the caloric cost per pound of live-weight beef produced varies from approximately 11,000 to 23,000 calories depending on the weight at slaughter, the age at separation from the

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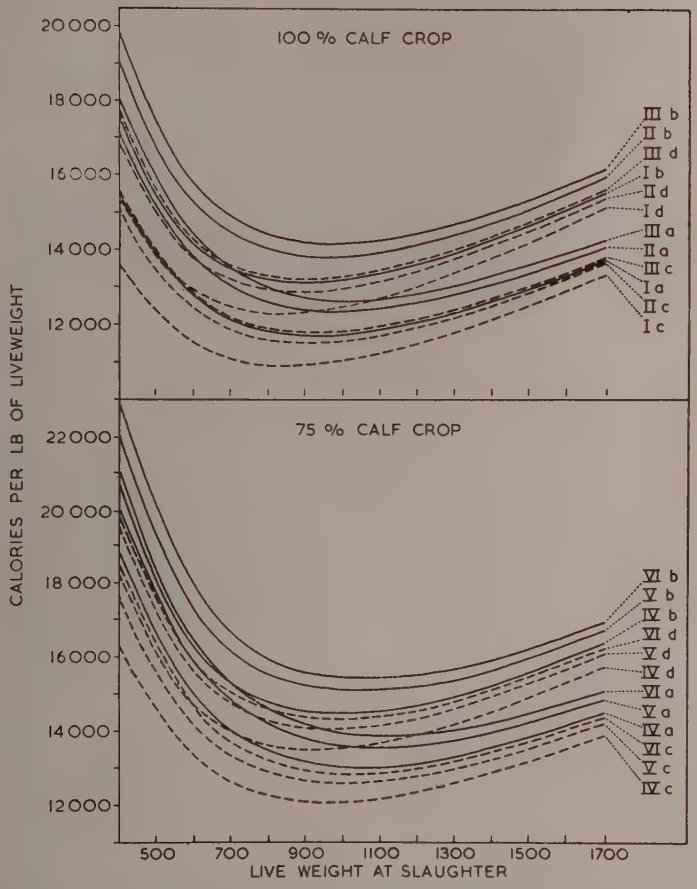


Fig. 1.—Theoretical energetic cost of raising calves at differential daily rates of gain to slaughter weights.

| Cow Weight 1,000 lb. | | | | | Cow Weight 800 lb. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Weaning (Days) | Daily Rate of Gain (lb.) | | Calf Crop | | Weaning (Days) | Daily Rate of Gain (lb.) | | Calf Crop | |
| | Birth-400 | 400+ | 100% | 75% | | Birth-400 | 400+ | 100% | 75% |
| Birth | 2 | 2 | Ia | IVa | Birth | 2 | 2 | Ic | IVc |
| | 1 | 1.5 | Ib | IVb | | 1 | 1.5 | Id | IVd |
| 120 | 2 | 2 | IIa | Va | 120 | 2 | 2 | IIc | Vc |
| | 1 | 1.5 | IIb | Vb | | 1 | 1.5 | IId | Vd |
| 180 | 2 | 2 | IIIa | VIa | 180 | 2 | 2 | IIIc | VIc |
| | 1 | 1.5 | IIIb | VIb | | 1 | 1.5 | IIId | VId |

dam, and the animal's daily rate of gain. The point of diminishing returns varies for each graph illustrated. It is lowest at approximately 11,000 calories when a calf out of an 800 lb. cow is separated from the dam at birth and averages 2 lb. bodyweight gain per day from birth to a live weight of approximately 900 lb (Ic). The point of diminishing returns is reached by the least efficient category illustrated at a body weight of approximately 1,100 lb. when a calf out of a 1,000 lb. cow with a 75% calf crop is weaned at 180 days and averages a daily gain of 1 lb. from birth to 400 lb. and 1½ lb. thereafter. For such an animal this point is approximately 15,500 calories per pound live weight (VIb). However, while the caloric cost per pound of bodyweight produced varies markedly from category to category illustrated, the point of diminishing returns only ranges from 850 to 1,100 lb. liveweight. In most of the categories it is reached in the live weight range of 900 to 950 lb. Interestingly, average killing weights in many areas of North America approximate this range, while in New Zealand killing weights for export ox and heifer beef average well in excess of 1,200 lb. liveweight. The four-year New Zealand carcass-weight average embracing the period 1949–1953 was 725 lb.[7].

Thus, it may be seen that while there is justification for killing New Zealand beef at much lighter weights, the recommendation that beef cattle in general should be killed at live weights of 800 lb. or less cannot be justified on a caloric basis unless the large maintenance cost of the cow is reduced by multiple births.

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# A NOTE ON THE DETOXICATION OF CYANIDE IN RUMINANTS

By N. A. Worker, Massey Agricultural College, Palmerston North

(*Received for publication, 20 March 1957*)

The detoxication of cyanide in the ruminant is a topic of considerable interest to biochemists in New Zealand since animals in this country graze throughout the year on pastures which for the most part contain a large proportion of high-HCN white clover.

Melville, Coop, Doak, and Reifer (1940), for example, have provided evidence to show that the free-grazing ruminant on improved pastures of average clover content here may consume daily up to eight times the lethal dose of cyanide. However, in considering the potential toxicity of white clover to animals grazing under New Zealand conditions, Doak (1935) could find no evidence to suggest the occurrence of any of the symptoms of cyanide poisoning or of any fatalities from this cause. It is apparent, therefore, that the mechanism of detoxication in the ruminant must be a comparatively efficient process.

It has long been recognized that one mechanism by which cyanide may be detoxicated in the animal body is by conversion to thiocyanate (Williams, 1947), an enzymic reaction involving the enzyme rhodanese (Lang, 1933). In sheep at least, Blakley and Coop (1949) have shown this to be the main mechanism, an observation which has been confirmed more recently by Flux *et al.* (1956) who noted a rapid and sustained rise in the serum thiocyanate values (from a mean level of 2.3 mg. up to a maximum of 17.6 mg./100 ml. plasma) of sheep transferred from low-clover to high-clover pastures. These results were felt to be of considerable significance in view of the known goitrogenic properties of thiocyanate (Bourne and Kidder, 1953).

In a survey of the serum thiocyanate values of Jersey milking cows carried out in this laboratory over the 1955–56 season, however, the content of high-HCN clover in the diet (which varied from a minimum of 17% to a maximum of 70%) was shown to be without effect on the level of thiocyanate present, the figure remaining constant at 2–3 mg./100 ml. plasma throughout. This result is somewhat surprising in view of the fact that bovine liver has been shown to contain quite appreciable amounts of rhodanese (Lang, 1933). While the difference may in part be explained by a more efficient urinary excretion of thiocyanate in the cow than in the sheep, it is quite possible that in the former species an alternative mechanism is present for detoxicating ingested cyanide. The matter is being further investigated.

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# OBSERVATIONS ON THE DISTRIBUTION, LIFE HISTORY, AND ECONOMIC IMPORTANCE OF *Nysius huttoni* (Lygaeidae: Hemiptera)

By L. Gurr, Massey Agricultural College, Palmerston North*

(*Received for publication, 21 February 1957*)

## Summary

*Nysius huttoni* is distributed throughout New Zealand and attacks a wide variety of cultivated plants and weeds.

Although it is one of the bugs responsible for the damage which causes the condition called "sticky dough" or "slimy gluten" when flour made from affected grain is used for baking, alternative uses for affected lines of wheat have reduced the economic loss from such damage.

Greatest economic loss is caused by its damage to cruciferous seedlings.

An account is given of the life history based on observations made in the field and laboratory at Nelson.

## Introduction

*Nysius huttoni* White was first described by Buchanan White (1878) from adult specimens collected by Hutton and Wakefield. Usinger (1943) examined 11 specimens and observed that they were so variable in colour and structure that two species may be represented in New Zealand. Apart from a brief description of the last ecdysis by Myers (1926) no account has been given of the nymphal stages of the insect. The following account records observations on its distribution, life history, and economic importance.

## Distribution

Hutton (1898) writes, "Canterbury and Otago, common . . .". In both these districts the author has been able to reaffirm this statement. It is common also in Blenheim, Nelson, North Canterbury and Central Otago. Myers (1926) gives the North Island localities, Te Paki, Kaitaia, Whangarei, Auckland, Ohakune, Hastings, Levin, Wellington, on the Tararua Range plentiful up to an altitude of 5,000 ft.; and at Stephen Island. Alfken (1903) and Kirkaldy (1909) have both recorded it from the Chatham Islands. It is thus widely distributed throughout New Zealand. Although the genus *Nysius* is cosmopolitan, *N. huttoni* seems to be confined to the N.Z. region.

## Host Plants, Habitat Choice, and Seasonal Movements

*N. huttoni* has been recorded (on file at Entomology Division, Department of Scientific and Industrial Research, Nelson) as attacking linen flax, various grasses, Nassella tussock, broom, strawberry, subterranean clover, wheat, and crucifers, as well as a large variety of weed plants. Myers (1921, 1926) records its occurrence on *Cassinia leptophylla* and damaging lucerne and red clover. Some of the largest

*The information here presented was gained while the author was a member of the staff of the Entomology Division, Department of Scientific and Industrial Research, Nelson, N.Z.

populations have been found by the author in association with the weeds shepherds purse (*Capsella bursa-pastoris* (L.) Medik.), twin cress (*Coronopus didymus* (L.) Sm.) and Curnow's curse (*Calandrinia caulescens* H.B.K.). The variety of host plants recorded shows that the bug is a very adaptable feeder and when the necessity arises can live on almost any cultivated plants as well as a variety of weeds. *N. huttoni* thrives best under hot, dry conditions and prefers situations where the direct sunlight strikes through to the ground; it is seldom found where the vegetation is so dense that it precludes this. Largest populations of *N. huttoni,* consequently, are found in the drier districts, i.e. South Canterbury and Central and North Otago.

Observations in the field have shown that the main feeding period is in the middle of the day and activity is accelerated or slowed up by the temperature. The bugs conceal themselves under clods or debris on the ground as soon as the temperature begins to fall in the evening and they do not become active in the morning until the day is advanced and the temperature has risen. Similarly rain inhibits activity.

At Nelson in 1952 active adults were last seen in the field on 14 May, while in 1953, 2nd instar nymphs were seen on 8 April and 5th instar nymphs as late as 12 May, and adults 14 May.

Adults were found overwintering under vegetable debris and at the base of weeds and grasses. First appearance of *Nysius* in the spring was noticed on 14 September 1951 and 19 September 1952. Only adults have been seen at the beginning of the spring, so it is likely that in Nelson only adults survive the winter.

## Life History

Copulating pairs were seen from October until early March.

Eggs were found in cracks in the soil. Other species of *Nysius* deposit their eggs in glumes of grasses, and in composite flowers and similar situations (Milliken, 1918, *N. ericae;* Smith, 1927, *N. vinitor;* Evans, 1943, *N. turneri;* Usinger, 1942, *N. coenosulus*) but although a careful search has been made in plants around which the bug congregates no eggs of *N. huttoni* have been found in or on plants.

A life-history study was carried out in an open insectary at normal temperature and humidity. On the day of the final moult from the final nymphal instar, pairs were confined in glass tubes closed at one end by a piece of gauze, and at the other by a plug of cotton wool. Each day they were given a fresh stem of shepherds purse and the cotton wool pad was changed. The pairs copulated freely and a variable time after reaching maturity the female began to oviposit in the cotton-wool plug (Table 1). The eggs were laid either singly or in clusters. If singly, they were generally laid on the surface of the cotton wool, if in clusters, buried up to 3 mm. below the surface. When first laid, the eggs were a creamy white but changed to a deep orange by the time they hatched.

Table 1 gives a summary of the egg-laying capabilities of 9 mated females studied in the laboratory.

An unmated female in the course of 43 days laid 76 eggs, these eggs remained creamy white in colour and did not get progressively darker in colour like the developing fertile ones. No correlation existed

TABLE 1. FECUNDITY OF NINE FEMALE *N. huttoni*

| Serial No. of Mated Bugs | Days after Final Ecdysis that Female Oviposites for First Time | Number of Eggs Laid | Oviposition Period in Days |
|---|---|---|---|
| A | 8 | 137 | 38 |
| B | 8 | 36 | 17 |
| C | 4 | 76 | 43 |
| D | 8 | 20 | 9 |
| E | 3 | 134 | 30 |
| F | 8 | 1 | 1 |
| G | 11 | 174 | 24 |
| H | 6 | 25 | 5 |
| I | 11 | 77 | 10 |

between air temperature or barometric pressure and the number of eggs laid, nor was there any apparent rhythm in the variation of numbers of eggs laid from day to day or over the whole period of egg-laying. The greatest number of eggs laid in a day by any female was 30. The total number of eggs laid by individual females varied between 1 and 174.

Under similar conditions and using the same apparatus to that of the egg-laying experiment, the hatching of the eggs and life history was studied. Table 2 gives the results obtained.

TABLE 2. DURATION IN DAYS OF INCUBATION PERIOD AND NYMPHAL INSTARS OF *N. huttoni*

| | | Incubation Period in Days | |
|---|---|---|---|
| | No. of Eggs | Mean | Range |
| | 37 | 9.5 | 8–11 |
| | | Duration of Nymphal Instars in Days | |
| Instar | No. of Nymphs | Mean | Range |
| 1st | 24 | 6 | 5–7 |
| 2nd | 17 | 5 | 4–7 |
| 3rd | 3 | 17 | 14–18 |
| 4th | 2 | 15 | 13–17 |
| 5th | 2 | 14 | 13–15 |

The moult from the 5th instar to the adult was observed on several occasions. This moult is initiated by a mesothoracic, mid-dorsal split; first the adult thorax comes out, next the head, legs, proboscis and antennae are freed; then a pause at this stage for several minutes. With a pulsating movement, the wings are freed, then slowly distended and finally the adult walks away from the exuvia. The accomplishment of one such moult took 15 minutes. Newly emerged adults are pale buff in colour and take some 12 hours to darken to the typical grey colour of the adult. The darkening takes place first on the head and thorax, then the abdomen, and finally the wings.

## ECONOMIC IMPORTANCE

Myers (1921, 1926) drew attention to this species by stating that it had done considerable damage to a crop of lucerne in the Wellington district and also had contributed to damage of another similar crop near Blenheim. Morrison (1939), after a preliminary survey of the wheat-growing areas of Canterbury and North Otago and a series of experiments carried out on screened wheat plots at Lincoln, established the fact that *N. huttoni* was one of the bugs responsible for the damage which caused the condition called "sticky dough" or "sticky gluten" when flour made from affected grain was used for baking. The bug attacks the wheat in the milk-ripe stage, piercing the grain and sucking some of the plant juices therefrom. In the process, a proteolytic enzyme is injected into the grain to facilitate ingestion of the plant juices, and it is the residue of this substance remaining in the damaged grain that interferes with the normal behaviour of the gluten. As little as 1% of bugged wheat used in the production of a flour has made it unusable for baking. Of 1,400 samples tested in 1950 at the Wheat Research Institute, Christchurch, 98 (7%) were definitely "bug wheat".

Bug-damaged wheat is easily recognized in the hand. The outer cheek of the grain shows an oval or round whitish patch, usually with a dark pin-prick mark in the centre; this is the feeding puncture and the damaged endosperm in its vicinity. So much endosperm is removed from some grains, presumably by prolonged or multiple feeding, that they become shrunken and cuboid in shape. Most millers are aware of the deterioration in baking quality of flour when bug wheat is used in the grist and examine each line of wheat for bug damage before milling it. Bug wheat may be used for flour without affecting its baking qualities if at blending it is mixed in quantities of less than 1% with unaffected lines. Otherwise the wheat may be sold as poultry food, either whole or ground for chick food.

Bug damage does not seem to affect germination for, in a private communication to the N.Z. Wheat Research Institute, Dr. F. W. Hilgendorf states: "Plainly bugged wheat and apparently unbugged wheat from the same line both germinated 90%". A heavy infestation may result in a greater proportion of second-grade wheat at harvest but, as no grains were seen to be totally destroyed, this appears to be the extent of the effect on the yield. *N. huttoni* also does considerable damage to young cruciferous crops. Feeding punctures are made around the stems of the seedlings at ground level and cause a cankerous growth of the tissue. This interferes with the sap flow and often results in the collapse of the plant. Rape, chou moellier, and turnips were thus affected in Marlborough, mid Canterbury, and Central Otago during 1950.

## DISCUSSION

*N. huttoni* is sporadic in occurrence in large numbers although almost universally present in small numbers in all agricultural areas of the South Island. Its habitat preference for hot, dry conditions makes it likely that population build up and consequent greater crop damage will occur in the drier districts. This in fact is the case. The majority of bugged-wheat lines come from South Canterbury, and Central and North Otago (Blair and Morrison 1949); these areas Garnier (1951) classifies as dry subhumid. In dry seasons, i.e. 1949–50, however, damage is more

widespread. Earlier in the season the bug is found in association with weeds, but as the season progresses most of these mature and dry off and by the time that wheat reaches the milk-ripe stage the bugs are forced to resort to this for food. Weeds are usually confined to the edge of wheat crops as they are smothered out by the dense growth of the crop. Small plantings of wheat have a greater proportion of edge in relation to area, hence more bug habitat and consequent likelihood of damage from the bug. This is confirmed by Mr. W. A. Pringle, head miller, Timaru Milling Co. Ltd. who states (pers. comm.) that, in his experience, most bug-wheat samples come from small lines. The whole of the area of seedling cruciferous crops, however, provides suitable bug habitat, so that damage is not confined to the edge of the crop. The spaces between the seedlings allow the sunlight to strike through to the ground and unless the crop is particularly weedy the seedlings are the principal food for the bugs. The damage caused by the feeding pressure of the bug is often severe, especially in dry districts and elsewhere in dry years when quite serious outbreaks occur.

The greatest economic loss, due to the depredations of the bug, is therefore suffered by the cruciferous crop growers, for the bug may destroy the whole plant in the seedling stage. To the wheat grower the loss in down grading of the grain is not great and the alternative uses for bug wheat does not necessitate a loss to the miller.

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# BIOCHEMICAL CHANGES DURING PARTIAL CURING OF TOBACCO LEAVES FOLLOWING REMOVAL OF MIDRIBS

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**Summary**

Tobacco leaves with their midribs removed are shown to undergo the same biochemical changes during colouring as entire leaves with evolution of carbon dioxide, hydrolysis of protein and production of sugars. It is suggested that the tradition that such leaves will not cure could have arisen through the early drying of such laminae. Maintaining a high degree of humidity of the air of the kiln would obviate this.

## Introduction

At various times statements have been made by those interested in the treatment of flue-cured tobacco leaves that curing will not take place unless the main vein or midrib is left with the leaf; in other words it is claimed that the lamina will not cure if isolated from the midrib. On the other hand suggestions have been made that for economy in fuel the lamina only should be cured, and therefore the midrib should be removed before the leaves are put into the kiln.

During some other work on the biochemical changes occurring in Virginia-type cigarette tobacco leaves, some work was done to see whether leaves freed from their midribs underwent the same changes as whole leaves during the early stages of curing. This paper reports the results of these experiments.

## Experimental

The tobacco plants (Harrison's Special) were grown outdoors at the Cawthron Institute in sand in large open-base cylinders and received nutrients equivalent to those supplied by an average rate of commercial fertilization. Some of the plants received no potash and others extra potash beyond that given in the full N-P-K treatment. In each experiment three leaves were taken at about 9 a.m. from a plant, the upper and lower ones being dried immediately for determination of dry matter contents, and the middle leaf being used in the apparatus previously described by Askew (1952). The requisite leaves were in the drying oven or in the experimental chamber about 20 minutes after picking, except in Exp. 4 where the time was 50 minutes. In the present experiments the air passing through the apparatus was at 80% R.H. after bubbling through a solution of ammonium sulphate. Evolution of carbon dioxide was measured at hourly or longer intervals by absorption in sodium hydroxide solution containing barium chloride. In the data reported, only the total amounts of carbon dioxide evolved by respiration at 32–33°c. are given. Four experiments are discussed in this paper, the first one with whole leaves and the other three with leaves from which the midribs had been removed. Analytical methods were as in the previous publication (Askew, 1952).

## Results

Data on the fresh weights of leaves used in the respiration experiments are given in Table 1. Dry weights were obtained by calculation

from the average percentages of dry matter in leaves immediately above and below the experimental leaves. Notes on the leaves are given at the bottom of Table 1. Each experiment lasted about 30–31 hours, with small overall losses of fresh weight of the leaves of 1.5 to 3.0 g. Apparent losses of dry matter, not very accurate owing to the possible differences between neighbouring leaves on a given plant, were calculated but are not reported here. The amounts of carbon dioxide evolved are given in the table. It is clear that respiratory losses per gramme of dry matter per hour are greater in the laminae than in the entire leaf (Exp. 1).

TABLE 1. CHANGES IN WEIGHT AND AMOUNTS OF CARBON DIOXIDE RESPIRED

| Exp. | Date | Time of Heating (hr.) | Fresh Wt. of Leaf (g.) | Loss of Weight (g.) | Dry Matter (g.) | $CO_2$ evolved (mg.) | Rate of Evolution of $CO_2$ (mg/g. of D.M./hr.) |
|---|---|---|---|---|---|---|---|
| 1 | 4.3.53 | 31.3 | 25.51 | 2.14 | 6.186 | 367 | 1.89 |
| 2 | 10.3.53 | 29.7 | 14.49 | 1.94 | 4.738 | 592 | 4.20 |
| 3 | 17.3.53 | 31.4 | 14.97 | 1.55 | 4.551 | 389 | 2.72 |
| 4 | 25.3.53 | 31.0 | 17.30 | 3.03 | 5.745 | 743 | 3.95 |

Notes: All leaves were picked when ripe on sunny mornings following a previous fine sunny day.

Exp. 1: Leaf from plant showing severe symptoms of K-deficiency. Leaf nicely yellowed at end of experiment.

Exp. 2: Leaf from just above those taken for Exp. 1. Deficiency symptoms not severe. More than half yellowed at end of experiment.

Exp. 3: From a plant receiving extra K in NPK fertilizer, from about same position on plant as for Exp. 2. Leaf three-fourths yellow at end of experiment.

Exp. 4: From a plant receiving NPK standard fertilizer. From about same position on plant as for previous experiments.

## CHEMICAL ANALYSES

Each of the three leaves taken in each experiment has been analysed. The leaves immediately above and below the experimental leaf were rapidly dried to minimize any changes, while the experimental leaf was dried rapidly on removal from the reaction chamber. Total ash, total alkalinity, and alkalinity of the soluble portion of the ash, total and protein (water-insoluble) nitrogen, total reducing sugars, and "sucrose" have been determined. The ash, alkalinity, and total-nitrogen figures are required for checking the similarity of the leaves to one another. For the experimental leaves the data are calculated back to the original dry-matter figure, the data so obtained having some uncertainty due to the difficulties in determining losses of dry matter during the respiration period. However the data of Table 2 for ash and alkalinity of the ash, and for total nitrogen in Table 3, show that the leaves within each experiment were comparable within themselves. The data of Table 3 for the top and bottom leaves for reducing sugars, "sucrose", total nitrogen, and proportion of the total nitrogen present in

TABLE 2. PERCENTAGES OF TOTAL ASH, AND ALKALINITY OF THE ASH, BEFORE AND AFTER RESPIRATION PERIOD
(Dry-matter basis)

| Exp. | Status of Leaf | Total Ash (%) | Total Alkalinity (m.e.%) | Soluble Alkalinity (m.e.%) |
|---|---|---|---|---|
| 1 Midrib not removed | Top | 8.2 | 177 | 128 |
| | Bottom | 8.7 | 189 | 148 |
| | Middle† | 9.2 | 175 | 133 |
| 2 Midrib removed | Top | 9.0 | 160 | 107 |
| | Bottom | 7.2 | 150 | 103 |
| | Middle† | 9.0 | 160 | 111 |
| 3 Midrib removed | Top | 6.1 | 107 | 55 |
| | Bottom | 7.5 | 115 | 60 |
| | Middle† | 6.1 | 105 | 54 |
| 4 Midrib removed | Top | 5.3 | 97 | 50 |
| | Bottom | 6.6 | 90 | 44 |
| | Middle† | 5.5 | 93 | 54 |

† Calculated on original dry matter basis after allowing for loss of dry matter during respiration period.
Alkalinity of the ash has been determined by titrating a boiled acidic solution of the ash with alkali to the phenolphthalein end point.

TABLE 3. TOTAL NITROGEN, PROTEIN NITROGEN, TOTAL REDUCING SUGARS AND "SUCROSE" BEFORE AND AFTER RESPIRATION PERIOD
(Dry-matter basis)

| Exp. | Status of Leaf | Total N (%) | Protein N in Total N (%) | Total Reducing Sugars (%) | Sucrose % |
|---|---|---|---|---|---|
| 1 Midrib not removed | Top | 1.07 | 72.9 | 2.42 | 0.68 |
| | Bottom | 1.10 | 62.7 | 2.87 | 1.36 |
| | Middle† | 1.13 | 57.4 | 5.48 | 3.53 |
| | | (1.22) | — | (5.93) | (3.82) |
| 2 Midrib removed | Top | 1.34 | 68.7 | 0.77 | 1.03 |
| | Bottom | 1.19 | 68.1 | 0.62 | 1.53 |
| | Middle† | 1.32 | 53.8 | 11.72 | 5.08 |
| | | (1.45) | — | (12.91) | (5.59) |
| 3 Midrib removed | Top | 1.13 | 59.3 | 1.02 | 2.04 |
| | Bottom | 1.14 | 64.9 | 1.25 | 2.51 |
| | Middle† | 1.15 | 50.7 | 6.43 | 3.56 |
| | | (1.38) | — | (7.75) | (4.29) |
| 4 Midrib removed | Top | 1.15 | 62.6 | 0.79 | 1.82 |
| | Bottom | 1.10 | 54.6 | 0.78 | 1.76 |
| | Middle† | 1.24 | 45.6 | 8.22 | 4.94 |
| | | (1.36) | — | (8.99) | (5.40) |

† On the original dry matter basis.
Note: Figures in brackets are uncorrected for loss of dry matter during respiration.

the protein form can be accepted as representing the original states of the middle (experimental) leaves. The data show too that the rapidly dried leaves were low in reducing sugars and "sucrose", and that a large proportion of the nitrogen present was in the protein form.

Analyses from the middle leaves from the four experiments show clearly that hydrolysis of protein and production of reducing sugars and "sucrose" took place whether the leaves had the midrib present (Exp. 1) or not (Exp. 2–4). In all cases, normal yellowing of the leaves took place during the period of respiration, just as occurs under the commercial conditions of curing of relatively low temperature and high humidity. In Exp. 2 and 4, production of sugars and hydrolysis of protein were particularly marked. Inspection of the data shows that increase in rate of evolution of carbon dioxide per gramme of dry matter is accompanied by increases in the hourly rates of hydrolysis of protein and of production of sugars. In particular, there is a linear relationship between hydrolysis of protein and production of sugars, hydrolysis of 0.1 g. of protein nitrogen being accompanied by the appearance of 13.6 g. of sugars, expressed as glucose. There does not seem to be any constant ratio between the reducing sugars and "sucrose" produced.

## Discussion

The data presented in this paper demonstrate quite clearly that removal of the midrib from tobacco leaves does not interfere with the respiratory processes in the lamina which lead to evolution of carbon dioxide, hydrolysis of protein, and production of sugars. It cannot be conceded therefore that removal of the midrib would prevent the curing of tobacco leaves under commercial conditions, except in the unlikely case that changes following on those taking place up to the end of the colouring period require the presence of the midrib for their completion.

It would seem that the tradition that tobacco leaves will not cure in the absence of the midrib has arisen from the circumstance that in ordinary kilns the lamina would dry out more rapidly than would an entire leaf; such early drying is well known as a cause of imperfect curing of tobacco leaves. In the present experiments the loss of water from the leaves was small during the approximately 30 hours of each experiment; indeed the moisture contents of the leaves at the end of the respiration periods were little different from those of the fresh leaves, as is shown by the following data:

TABLE 4. Moisture Content %

| Experiment | Fresh Leaves | After Respiration Period |
|---|---|---|
| 1 | 75.8 | 75.6 |
| 2 | 67.3 | 62.2 |
| 3 | 68.8 | 71.8 |
| 4 | 66.8 | 63.9 |

It is suggested therefore that if attempts were made on a commercial scale to cure leaves freed from their midribs particular attention would need to be given to maintenance of sufficiently high humidities in the air of the kilns. With the down-draught types of kilns coming into use in the Nelson district this could probably more easily be obtained than with the earlier conventional type of kiln.

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# INCIDENCE AND PARASITISM OF INSECT PESTS OF CRUCIFEROUS CROPS IN HAWKE'S BAY, WAIRARAPA, AND MANAWATU, 1955-56

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*(Received for publication, 3 January 1957)*


## Summary

Little damage to crucifer crops was observed in Hawke's Bay, Wairarapa, and Manawatu during the 1955–56 season.

A virus disease, common in all districts, reduced populations of white butterfly, *Pieris rapae* (L.), to the point where only small numbers of healthy larvae could be collected. No larval parasites, *Apanteles glomeratus* (L.), were recovered. Where pupae could be collected, there was heavy parasitism by *Pteromalus puparum* (L.).

There was a low incidence of diamond-back moth, *Plutella maculipennis* Curtis, in all areas. Prepupae and pupae collected were heavily parasitized by *Angitia cerophaga* (Gravenhorst). Adults of this parasite were frequently seen in the crops.

From the aphid material collected, two species of parasites were recovered, *Diaeretus rapae* (McIntosh), a primary, and *Lygocerus niger* (Howard), a hyperparasite.


## Introduction

The three most important insect pests of cruciferous crops in New Zealand are the white butterfly, *Pieris rapae* (L.), the diamond-back moth, *Plutella maculipennis* Curtis, and the cabbage aphid, *Brevicoryne brassicae* (L.).

The white butterfly first made its appearance at Napier in 1930, and by the following year it had spread one hundred to one hundred and twenty miles from the initial point of infestation. By 1935–36, its invasion of New Zealand was complete (Muggeridge 1942). In 1932, a larval parasite, *Apanteles glomeratus* (L.), was introduced, and the first field liberations were made in Hawke's Bay during the latter part of that year. A pupal parasite, *Pteromalus puparum* (L.), was introduced the following year, and soon proved itself to be an efficient controlling agent.

The diamond-back moth is known to have been present in New Zealand for more than seventy-five years. In 1930, it was realized that this pest was responsible for a large reduction in the yield of the cruciferous crops in this country (Robertson 1939), and that some effort should be made to reduce its depredations. Work on biological control was immediately undertaken, primarily to ascertain what parasites and predators were already present in New Zealand, and, if possible, to improve the degree of control by the importation of further parasites. Unfortunately, at this stage it was not possible to proceed with parasite introduction, and it was not until 1936 that a larval parasite, *Angitia cerophaga* (Gravenhorst), was imported from England. In the following year (1937), a pupal parasite, *Diadromus collaris* (Gravenhorst), was introduced. Both these parasites were successfully established and became very active agents in the control of the moth.

The cabbage aphid, which is almost cosmopolitan, has become a serious pest in New Zealand, causing considerable damage to cruciferous

crops particularly during dry seasons when the plants succumb more readily to attack. Plants grown for seed are particularly susceptible. The cabbage aphid is attacked by a small braconid parasite, *Diaeretus rapae* (McIntosh), which apparently has been introduced with its host.

During the summer of 1955–56, field collections were made from 36 cruciferous crops growing in Hawke's Bay, Wairarapa, and Manawatu districts, which are the important crucifer-growing areas of the North Island. The following account details observations made on the incidence of the pests in these districts during the past season and records the percentage of parasitism.

## METHODS AND RESULTS

In order to determine the degree of parasitism being attained in the field by the parasites, it was first necessary to make collections of their hosts, which were then transferred to the laboratory for further observations.

A sampling method was adopted for collecting white-butterfly larvae and the prepupae and pupae of the diamond-back moth. Random collections of 10-minutes' duration were decided upon as a minimum, and to ensure that a representative sample of the population was obtained, care was taken to work from the edge of the crop to the centre. This method of judging infestation on a time basis is one that has been worked out from experience and has given satisfactory results to date for comparing relative infestations from one year to another.

When collecting butterfly larvae, an endeavour was made to select non-virus-infected final-instar specimens, which were placed in cylindrical wire-gauze rearing cages with muslin ends. Fresh chou moellier leaves were fed to the larvae every second day. This type of cage, which was held in a horizontal position, proved extremely satisfactory in that the perforated gauze allowed for a good circulation of air and the individual perforations were sufficiently large to allow most of the frass to fall through, thus limiting the chances of fungal infection which is frequently encountered when rearing caterpillars under laboratory conditions. When development of the larvae was complete, all the material was examined for parasitism. A large proportion of the apparently healthy larvae collected on the second survey subsequently developed the symptoms of virus and died in the rearing cages before completing their development.

Only random collections of white-butterfly pupae were possible, and no steps were taken to ensure that a representative sample of the population was obtained from any one group. The pupae collected were placed in parasite emergence cans where they were periodically examined for parasitism.

The field-collected diamond-back moth prepupae and pupae were placed in glass tubes closed at both ends with muslin. This method allowed for early observation of any emerging parasites.

The technique employed for handling the aphid-infested material was the same as that used for the diamond-back moth.

The first survey was commenced in late November, 1955, and was primarily for the purpose of selecting suitable crops from which the

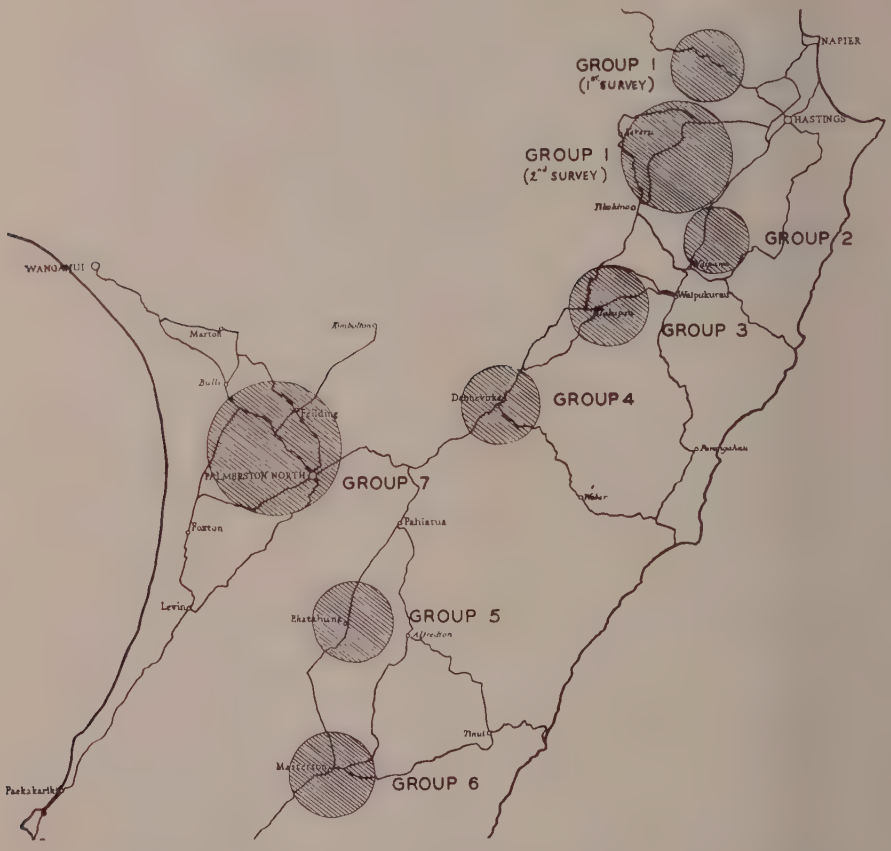


Fig. 1.—Areas surveyed and distribution of groups.

| | |
|---|---|
| Group 1 — Fernhill (1st Survey) | Group 4 — Dannevirke |
| „ 1 — Maraekakaho (2nd Survey) | „ 5 — Eketahuna |
| „ 2 — Otane | „ 6 — Masterton |
| „ 3 — Takapau Plains | „ 7 — Palmerston North |

second collection of the pests could be made later in the season. Groups of crops were selected in the following areas (Fig. 1).

With the exception of groups five and seven, which consisted of four and seven crops respectively, the groups contained five crops each. The crops were suitably spaced within the groups so that the material collected from any one of them would be reasonably representative of that particular district.

Wherever possible, chou moellier crops were chosen, for they normally have a longer and less disturbed growing period than other

TABLE 1. COLLECTION OF *P. rapae* LARVAE IN FIELD 1955–56

| 1st Survey | | | | | | 2nd Survey | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Group | Crop | Variety* | Date Collected | Duration of Collection in mins. | No. Collected | Group | Crop | Variety* | Date Collected | Duration of Collection in mins. | No. Collected |
| 1 | A | R | 29.11.55 | 30 | 7 | 1 | A | C | 14.3.56 | 10 | 0 |
| | B | R | ,, | ,, | 13 | | B | C | ,, | ,, | 0 |
| | C | R | ,, | ,, | 0 | | C | C, T | ,, | ,, | 0 |
| | D | R | ,, | ,, | 11 | | D | C | ,, | ,, | 0 |
| | E | R | ,, | ,, | 2 | | E | C | ,, | ,, | 0 |
| 2 | A | R, T | 30.11.55 | 30 | 8 | 2 | A1 | S | 13.3.56 | 10 | 0 |
| | B | S | ,, | ,, | 0 | | B1 | C | ,, | ,, | 0 |
| | C | C | ,, | ,, | 8 | | C | C | ,, | ,, | 0 |
| | D | R | ,, | ,, | 0 | | D1 | C | ,, | ,, | 0 |
| | E | C | ,, | ,, | 13 | | E | C | ,, | ,, | 0 |
| 3 | A | S | 30.11.55 | 30 | 9 | 3 | A1 | C | 12.3.56 | 10 | 0 |
| | B | R | ,, | ,, | 5 | | B1 | C | ,, | ,, | 0 |
| | C | R | 1.12.55 | ,, | 4 | | C1 | C | ,, | ,, | 0 |
| | D | C | ,, | ,, | 6 | | D1 | C, S | ,, | ,, | 0 |
| | E | R | ,, | ,, | 12 | | E1 | C | ,, | ,, | 0 |
| 4 | A | C | 12.1.56 | — | — | 4 | A | C | 16.3.56 | 10 | 0 |
| | B | C | ,, | 15 | 8 | | B | C | ,, | ,, | 0 |
| | C | C | ,, | ,, | 21 | | C | C | 29.2.56 | ,, | 162 |
| | D | S | ,, | ,, | 2 | | D1 | C | 16.3.56 | 20 | 151 |
| | E | C, S | ,, | ,, | 10 | | E | C, S | ,, | 10 | 93 |
| 5 | A | C, S, T | 12.1.56 | 15 | 10 | 5 | A1 | C, K | 15.3.56 | 10 | 0 |
| | B | T | ,, | ,, | 0 | | B1 | C, S | ,, | ,, | 0 |
| | C | C | ,, | ,, | 7 | | C | C | ,, | — | — |
| | D | S | ,, | ,, | 0 | | D | S | ,, | 10 | 0 |
| 6 | A | R | 7.12.55 | 30 | 5 | 6 | A1 | K | 15.3.56 | 10 | 0 |
| | B | C, S | ,, | ,, | 4 | | B | C, S | ,, | ,, | 0 |
| | C | R | ,, | ,, | 7 | | C1 | C | ,, | ,, | 0 |
| | D | C, S | 8.12.55 | ,, | 39 | | D | C, S | ,, | ,, | 0 |
| | E | C, T | ,, | ,, | 8 | | E1 | S | ,, | ,, | 87 |
| 7 | A | C | 16.1.56 | 20 | 40 | 7 | A | C | 23.3.56 | 10 | 0 |
| | B | T | ,, | 10 | 13 | | B | T | ,, | ,, | 0 |
| | C | C, S | 19.1.56 | 20 | 52 | | C | C, S | ,, | ,, | 0 |
| | D | C | ,, | ,, | 36 | | D | C | ,, | ,, | 0 |
| | E | C, S | ,, | ,, | 15 | | E | C, S | ,, | ,, | 0 |
| | F | S | ,, | ,, | 16 | | F | S | ,, | ,, | 0 |
| | | | | | | | G | C | ,, | ,, | 0 |

"1" as in "A1" indicates alternative crop from the original.

No parasitism by *A. glomeratus* was found in either the first or the second survey. During the second survey there was a considerable amount of virus infection throughout all the crops visited, and for this reason the figures obtained were not for total populations, but only for apparently healthy larvae.

*C = Chou moellier; K = Kale; R = Rape; S = Swede; T = Turnip.

TABLE 2. FIELD COLLECTION OF *P. maculipennis* INCLUDING PERCENTAGE PARASITISM* BY *A. cerophaga* AND *D. collaris* 1955–56

| | 1st Survey | | | | | | | 2nd Survey | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group | Crop | Variety‡ | Date Collected | Duration of Collection in mins. | No. Collected | % Parasitism by *A. cerophaga* | Group | Crop | Variety‡ | Date Collected | Duration of Collection in mins. | No. Collected | % Parasitism by *A. cerophaga* |
| 1 | A | R | 29.11.55 | 30 | 0 | — | 1 | A1 | C | 14.3.56 | 10 | 0 | — |
| | B | R | ,, | ,, | 5 | 80 | | B1 | C | ,, | ,, | 0 | — |
| | C | R | ,, | ,, | 0 | — | | C1 | C, T | ,, | ,, | 1 | 100 |
| | D | R | ,, | ,, | 2 | 100 | | D1 | C | ,, | ,, | 0 | — |
| | E | R | ,, | ,, | 0 | — | | E1 | C | ,, | ,, | 0 | — |
| 2 | A | R, T | 30.11.55 | 30 | 0 | — | 2 | A1 | S | 13.3.56 | 10 | 0 | — |
| | B | S | ,, | ,, | 0 | — | | B1 | C | ,, | ,, | 0 | — |
| | C | C | ,, | ,, | 0 | — | | C | C | ,, | ,, | 0 | — |
| | D | R | ,, | ,, | 0 | — | | D1 | C | ,, | ,, | 0 | — |
| | E | C | ,, | ,, | 0 | — | | E | C | ,, | ,, | 0 | — |
| 3 | A | S | 30.11.55 | 30 | 0 | — | 3 | A1 | C | 28.2.56 | 10 | 1 | 100 |
| | B | R | ,, | ,, | 0 | — | | B1 | C | 12.3.56 | ,, | 0 | — |
| | C | R | 1.12.55 | ,, | 0 | — | | C1 | C | ,, | ,, | 0 | — |
| | D | C | ,, | ,, | 0 | — | | D1 | C, S | ,, | ,, | 0 | — |
| | E | R | ,, | ,, | 0 | — | | E1 | C | ,, | ,, | 0 | — |
| 4 | A | C | 12.1.56 | | — | | 4 | A | C | 16.3.56 | 10 | 0 | — |
| | B | C | ,, | 15 | 5 | 60 | | B | C | ,, | ,, | 0 | — |
| | C | C | ,, | ,, | 5 | 80 | | C | C | ,, | ,, | 0 | — |
| | D | S | ,, | ,, | 1 | 100 | | D1 | C | ,, | ,, | 0 | — |
| | E | C, S | ,, | ,, | 0 | — | | E | C, S | ,, | ,, | 0 | — |
| 5 | A | C, S | 12.1.56 | 15 | 22 | 86 | 5 | A1 | C, K | 15.3.56 | 10 | 0 | — |
| | B | T | ,, | ,, | 0 | — | | B1 | C, S | ,, | ,, | 0 | — |
| | C | C | ,, | ,, | 4 | 100 | | C | C | ,, | ,, | 0 | — |
| | D | S | ,, | ,, | 0 | — | | D | S | ,, | ,, | 0 | — |
| 6 | A | R | 7.12.55 | 30 | 12 | 75 | 6 | A1 | K | 15.3.56 | 10 | 0 | — |
| | B | C, S | ,, | ,, | 0 | — | | B | C, S | ,, | ,, | 0 | — |
| | C | R | ,, | ,, | 0 | — | | C1 | C | ,, | ,, | 0 | — |
| | D | C, S | 8.12.55 | ,, | 0 | — | | D | C, S | ,, | ,, | 0 | — |
| | E | C, T | ,, | ,, | 5 | 80 | | E1 | S | ,, | ,, | 0 | — |
| 7 | A | C | 16.1.56 | 20 | 1 | 100 | 7 | A | C | 23.3.56 | 10 | 2 | 100 |
| | B | T | ,, | 10 | 0 | — | | B | T | ,, | ,, | 0 | — |
| | C | C, S | 19.1.56 | ,, | 1 | 100 | | C | C, S | ,, | ,, | 0 | — |
| | D | C | ,, | ,, | 0 | — | | D | C | ,, | ,, | 0 | — |
| | E | C, S | ,, | ,, | 0 | — | | E | C, S | ,, | ,, | 0 | — |
| | F | S | ,, | ,, | 0 | — | | F | S | ,, | ,, | 0 | — |
| | | | | | | | | G | C† | ,, | 30 | 35 | 60 |

*Calculations based on the number of parasites emerging in laboratory.

†Parasitism by *D. collaris* was found in only one instance when 14.3% was recorded from crop 7G in the second survey.

"1" as in "A1" indicates alternative crop from the original.

‡C = Chou moellier; K = Kale; R = Rape; S = Swede; T = Turnip.

TABLE 3. PERCENTAGE PARASITISM OF *P. rapae* PUPAE BY *P. puparum* IN FIELD COLLECTIONS 1955–56

| Group | Crop | Date Collected | Duration of Collection in mins. | No. Collected | % Parasitism |
|---|---|---|---|---|---|
| 3 | B1 | 28.2.56 | 20 | 153 | 94.8 |
| 3 | C | 12.3.56 | 10 | 89 | 93.3 |
| 3 | D | „ | „ | 81 | 98.8 |
| 4 | A | „ | 20 | 86 | 97.7 |
| 4 | C | 29.2.56 | „ | 133 | 75.2 |
| 4 | C | 16.3.56 | 10 | 91 | 96.7 |
| 6 | C1 | 15.3.56 | „ | 37 | 97.3 |
| 6 | E1 | „ | „ | 83 | 93.9 |
| 7 | E | 23.3.56 | 20 | 64 | 100.0 |

crucifers, this factor being important in such a survey. On the first survey, a number of rape crops were selected but unfortunately most of these had been fed off to stock between the two surveys, making it necessary to select alternative crops in close proximity to the original ones. The Fernhill area was most seriously affected in this respect and Group 1 was ultimately transfered to the Maraekakaho-Tikokino area.

The results of the field collection of the white butterfly and diamond-back moth in Hawke's Bay, Wairarapa, and Manawatu during 1955–56, are given in Tables 1, 2, and 3.

The crops examined during the first survey were newly established and in an extremely clean and healthy condition. Even when hot sunny days prevailed, only very small numbers of white butterflies could be seen in flight over the crops, and in some instances they were entirely absent. Neither eggs nor larvae were readily found. Frequently a search of 30-minutes' duration failed to reveal a single one. At this stage there were no virus-infested larvae present on any of the crops examined, and no pupae were recovered.

A search of the crops for the presence of the diamond-back moth frequently proved negative.

On most of the crops examined, the cabbage aphid was present, but in no instance was the degree of infestation great enough to affect the vigour of the plants. Specimens of both the primary parasite *D. rapae* and the hyperparasite *Lygocerus niger* (Howard), emerged from the infested material collected.

During mid March 1956, a second survey was carried out. As far as possible collections were made from the crops originally selected. However, as has been indicated previously, a number of these crops had been fed off, making it necessary to find alternative ones.

White butterfly activities had increased considerably since the earlier surveys. Large populations of adults were observed flying over

a number of the crops, particularly in the Takapau Plains and Palmerston North areas (groups 3 and 7 respectively). Moderate numbers of eggs and all stages of the larvae were present on most of the crops examined. Owing to the prevalence of the virus, however, the symptoms of which are typical of the "flacherie" or "wilt" referred to by Muggeridge (1933) it appeared that a small percentage only of the larval population succeeded in reaching maturity. Even the smallest larvae were affected, and, on close examination of the plants, many dead early-instar larvae were found. There was sufficient evidence to show that the presence of the virus in the field at the latter end of the season was responsible to a large degree for the cessation in the development of the larval population, thus preventing any significant crop damage.

A number of the crops had been subjected to a minor attack by the white butterfly at some period between the two surveys. This was suggested by the fact that plants growing on the edges of the crops in question showed typical larval injury and moderate numbers of pupae could be readily found on the fence posts and grass stalks. Any damage occurring was however, of a minor nature and confined entirely to the edges of the crops.

A low incidence of diamond-back moth still prevailed, and there was nothing to indicate that there had been a serious outbreak of this pest in any of the districts visited. Only small numbers of prepupae and pupae were collected.

The aphid *B. brassicae* was present on all the crops examined, the population density varying with individual crops. A heavily infested chou moellier and swede crop, situated in the Palmerston North area, showed severe wilting of the chou moellier plants and a complete disappearance of the swede foliage. With this exception, no serious outbreak of the pest was recorded. From the aphid-infested material collected, it was apparent that the primary parasite, *D. rapae,* parasitizes a considerable percentage of *B. brassicae.*

## Discussion

Field observations, analysis of field-collected samples, and discussions with officers of the Department of Agriculture and individual farmers, have enabled the importance of the major pests of cruciferous crops in the areas visited to be assessed with some accuracy.

Both the white butterfly and the diamond-back moth, which at one time were considered to be the two most serious crucifer pests in New Zealand, now appear to be effectively checked by parasites (with the assistance of the virus in the case of the white butterfly) and rarely become of more than minor importance.

Fluctuations in the population density of the white butterfly and diamond-back moth occur from place to place and from time to time, but, owing to the efficiency of the parasites, any such local build up of the hosts is usually of a temporary nature.

While the presence of the virus is obviously an important factor in checking the white butterfly, it is reasonable to assume that its prevalence in the field is having a detrimental effect on the larval parasite, *A. glomeratus,* for when the host is heavily infected it is inevitable that

many of the parasitized larvae must die before the parasites are able to complete their development.

The cabbage aphid *B. brassicae* is potentially the most serious economic pest of crucifers in New Zealand at the present time. Its attacks are sporadic, but, if climatic conditions are favourable, it will develop with remarkable rapidity and is capable of causing severe damage to the extensively grown cruciferous crops which are essential for seed production, winter fodder, and the fattening of stock for export. The braconid parasite, *D. rapae,* although parasitizing a considerable percentage of *B. brassicae,* is of little value as a means of reducing the depredations of the aphid, and its failure to reach significant proportions as a parasite is partly due to hyperparasitism.

Although collections have not been made comprehensively throughout New Zealand, the districts examined are the most important areas of cruciferous crops in the North Island, for, of a total of 198,806 acres grown in the 1954–55 season, 103,379 acres were located in Hawke's Bay, Wairarapa, and Wellington, in which provinces the field surveys were made. By a continuation and extension of the present type of survey, it should be possible to determine with some degree of accuracy the relative importance of the cruciferous pests and the efficiency of their parasites throughout the whole of New Zealand.

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# TRIALS FOR CONTROL OF CHRYSANTHEMUM GALL MIDGE (*Diarthronomyia chrysanthemi* Ahlberg)

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## Summary

Spray trials for control and prevention were carried out against the chrysanthemum gall midge *Diarthronomyia chrysanthemi* Ahlberg on cultivated chrysanthemums.

Parathion sprays, at concentrations of 0.025% and 0.0125%, when applied once weekly were effective in preventing infestation and also gave good control of insects within the galls. When applied once every two weeks prevention was poor but it was still effective for control of an infestation. In each trial parathion was outstandingly better than the other materials tested, namely, nicotine sulphate, gamma BHC, and DDT. DDT was ineffective in both trials.

There was a wide range of susceptibility to attack amongst 43 varieties of cultivated chrysanthemum tested for varietal resistance. None was immune, but the varieties Chartreuse Rialgar, Dulcina, and Frances were little attacked, while the varieties Lesma Day, Mrs. W. Duckham, and Venice had heavy infestations.

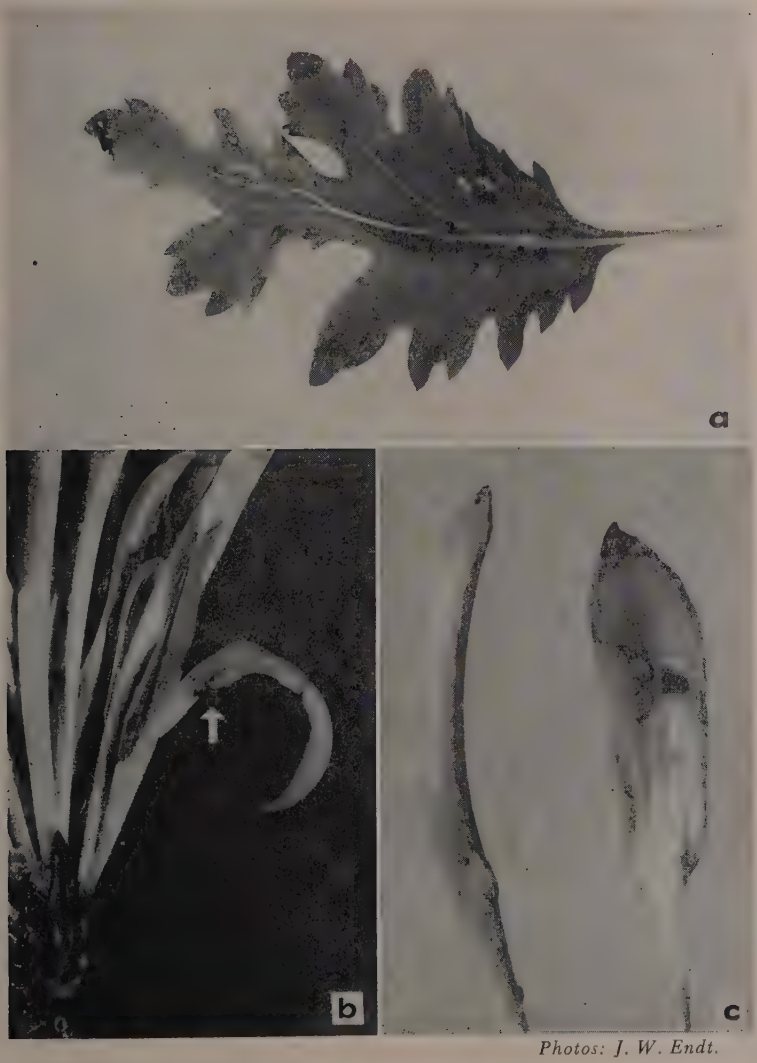
## Introduction

The chrysanthemum gall midge (*Diarthronomyia chrysanthemi* Ahlberg, 1939) was first recorded in New Zealand by Lamb (1954). Chrysanthemums are grown outdoors in this country and the midge when first discovered in Auckland, in April 1953, had already become a serious pest in some areas. Since then it has spread throughout the Auckland district and further south. It is also recorded from Palmerston North, Hastings, and Gisborne, and may be distributed throughout the North Island.

## Life History

Adult midges usually live only one or two days. They emerge in the early morning and mate soon after emergence. Eggs, which are laid on buds and young leaves, hatch after an incubation period of several days. The young larvae move about on the surface of the plant for a few hours then bore into the plant tissue and become completely enclosed within twenty-four hours of hatching (Barnes, 1948). The presence of larvae in plant tissues causes the formation of galls. Galls may form on both upper and lower surfaces of leaves and on stems, buds, and calices (Barnes, 1948). In New Zealand they have also been found on petals of the fantasy variety Bronze Tokio (Fig. 1, b, c). When fully formed the galls are conical outgrowths measuring about 2 mm. in length (Fig. 1, a). Each gall contains one larva and this pupates within the gall. After emergence of the adult, the pupal skin is often left protruding from the apex of the gall.

The length of life-cycle varies considerably. In England the duration of the larval stage varies from two weeks to several months, the pupal stage from six days to several weeks, and the complete egg-to-adult period from twenty-six days to several months (Barnes, 1948). There has been no detailed study of the life-history in New Zealand, but some information is available from the trials recorded below where the formation of galls and the emergence of adult insects were used as criteria for the assessment of prevention and control respectively. Galls containing larvae or pupae were designated "new galls", and empty galls, from which adult midges had emerged, were designated "old




*Photos: J. W. Endt.*

Fig. 1.—Galls of *Diarthronomyia chrysanthemi* Ahlberg on Chrysanthemums. a. Galls on leaf; b., c. Galls on petals.

galls". Counts on check plants showed that there were, in some cases, more old galls at the end of two weeks than the total number of new and old galls present at the beginning of that period. Thus the gall period of some of the insects was less than two weeks. Further, most midges had emerged from first-formed galls within four weeks of their formation. Distribution of emergence times, from 1840 galls on check plants, is shown in Table 1. At the beginning of Trial I the first signs of gall formation did not appear until the end of the third week. Assuming that eggs were laid on check plants within the first few days of

the trial it would appear that the minimum period for the life-cycle was less than five weeks.

TABLE 1. DISTRIBUTION OF EMERGENCE TIMES OF ADULT MIDGES FROM HARBINGER CHRYSANTHEMUMS

| Period from Formation of Gall to Emergence of Adult Midge (Weeks) | Numbers of Emergences | % Emergence |
|---|---|---|
| 0–2 | 68 | 3.7 |
| 2–4 | 1232 | 67.0 |
| 4–6 | 540 | 29.3 |
| | 1840 | 100.0 |

## SPRAY TRIALS FOR PREVENTION AND CONTROL

During the 1953–54 and 1954–55 seasons, spray trials were carried out, the aims being first to prevent infestation and second to kill insects in plants already infested. The former is more important as the main damage to plants is distortion caused by gall formation.

Preliminary trials in the first season showed that parathion was effective in control. Gamma BHC and nicotine sulphate had some effect but DDT and schradan (Pestox III) were ineffective. DDT was included in subsequent trials as it is often recommended overseas.

Trials were carried out in an insectary using plants of the cultivated chrysanthemum variety Harbinger. These were grown in six-inch pots standing in trays. When the plants were watered, care was taken not to wet the foliage and thus none of the spray was washed off.

### *Trial I*

Plants used in this trial had been kept in a glasshouse and were initially free from infestation. When the first spray was applied the plants were taken into the insectary where other plants, heavily infested, provided the source of infestation. The trial continued for ten weeks from the first spray application. There were six plants for each treatment.

Spray treatments were as follows:

| | | |
|---|---|---|
| Black Leaf 40 (40% nicotine sulphate) | 2 pt. per 100 gal. water | weekly |
| " " " " " " | 1¾ " " " " " | weekly |
| Folidol E605 (25% parathion) | 1 lb. " " " " | weekly |
| " " " " | 1 lb. " " " " | two-weekly |
| " " " " | ½ lb. " " " " | weekly |
| " " " " | ½ lb. " " " " | two-weekly |
| Lethalin (20% gamma BHC emulsion) | 1 lb. " " " " | weekly |
| " " " " " | 1 lb. " " " " | two-weekly |
| " " " " " | ½ lb. " " " " | weekly |
| Trimort DDT (20% p.p.i.DDT emulsion) | 1 lb. " " " " | weekly |
| " " " " " " | ½ lb. " " " " | weekly |

There were 10 weekly applications and 5 two-weekly applications in the main trial and one further application of all treatments at the beginning of an additional week (see below).

Counts of new and old galls were taken at two-weekly intervals. The efficacy of the various materials in preventing infestation was evaluated by counting the numbers of new galls formed.

In the above trial none of the insecticides entirely prevented gall formation. Therefore it was necessary to determine whether any one of the insecticides would give additional control by killing the insects in the galls. The proportion killed in this way has been computed from the two-weekly counts of new and old galls and an additional final count made one week after the last count of the main experiment.

Results are given in Table 2.

TABLE 2. PERCENTAGES OF PREVENTION AND CONTROL OF CHRYSANTHEMUM GALL MIDGE OBTAINED AFTER SPRAYING WITH A RANGE OF INSECTICIDES

| Treatments | | TRIAL I | | | | | TRIAL II† |
|---|---|---|---|---|---|---|---|
| | | Prevention of Infestation | | | Control of Insect in Galls | | |
| | | No. of Spray Appl. and Intervals Between | Mean No. New Galls per Plant | % Prevention | No. of Spray Appl. and Intervals Between | % Control | % Control of Existing Infestation |
| Nicotine sulphate | 0.1% | 10W* | 221 | 77.4 | 11W | 46.4 | 37.1 |
| „ „ | 0.08% | 10W | 381 | 61.2 | 11W | 33.0 | 16.2 |
| Parathion | 0.025% | 10W | 93 | 90.5 | 11W | 100.0 | 92.3 |
| „ | 0.025% | 5WW* | 702 | 28.3 | 6WW | 99.6 | — |
| „ | 0.0125% | 10W | 146 | 85.1 | 11W | 100.0 | 85.8 |
| „ | 0.0125% | 5WW | 755 | 23.0 | 6WW | 95.0 | — |
| Gamma BHC | 0.02% | 10W | 462 | 52.9 | 11W | 60.3 | 19.4 |
| „ | 0.02% | 5WW | 731 | 25.4 | 6WW | 37.1 | — |
| „ | 0.01% | 10W | 547 | 44.2 | 11W | 31.7 | 1.9 |
| DDT | 0.02% | 10W | 997 | 0 | 11W | 3.3 | 1.0 |
| „ | 0.01% | 10W | 951 | 2.8 | 11W | 0.7 | 0 |
| Check | | | 979 | 0 | | 0 | 0 |
| Differences for significance at | | .05 | | 18.5 | | 13.5 | 15.1 |
| | | .01 | | 24.7 | | 18.1 | 20.3 |

* 10W = 10 weekly applications. 5WW = 5 two-weekly applications.
† 3 applications of spray treatments at weekly intervals.

*Trial II*

Heavily infested plants were used in this trial. Before the first spray was applied, all superfluous leaves were removed and only a small group of young leaves, showing many new galls but few old galls, remained at the top of each plant. Treatments were the same as weekly treatments in Trial I. Each spray was applied to six plants on three occasions at weekly intervals. Counts were made of galls present at the beginning of the trial and of old galls present after three weeks, the insecticides being evaluated on the basis of numbers of old galls in relation to the number of new galls at the beginning of the trial.

Results are given in Table 2.

## RESULTS

In Trial I the number of galls formed was not significantly reduced by DDT sprays applied either weekly or two-weekly. All other sprays gave a significant reduction in gall formation when applied weekly. Parathion gave the best control, being particularly effective when applied at the stronger concentration. Complete control of insects within the galls was obtained with both concentrations of parathion when applied weekly and almost complete control when applied two-weekly. None of the other materials approached parathion in effectiveness, while DDT was quite ineffective.

In Trial II parathion gave good control, nicotine sulphate and gamma BHC gave poor control, and DDT was ineffective.

## VARIETAL RESISTANCE TRIAL

A trial of varietal resistance of chrysanthemums to gall-midge attack was carried out during 1953–54 on 43 varieties of *Chrysanthemum* sp. cult. *Chrysanthemum leucanthemum* L., which is known to be resistant to gall midge attack (Barnes, 1948), was included in the trial as a basis of comparison. The trial was set up, on 16 October 1953, in an insectary, with four plants of each variety, the plants being distributed at random within each replication. At the beginning of the trial some plants were already infested and further infestation was gained by placing other infested plants around the trial plants.

Varieties were sampled four times by removing four leaves, two from crown and two from stem, from each plant every two weeks from 23 February to 5 April 1954. The average number of galls per leaf-sample for each variety (Table 3) is taken as a measure of the resistance to infestation of that variety.

The range of resistance to attack was very wide. No variety of cultivated chrysanthemum was immune, but the varieties Chartreuse Rialgar, Dulcina, and Frances were little attacked while the varieties Lesma Day, Mrs. W. Duckham, and Venice had heavy infestations. Thus it is established that different varieties of chrysanthemums differ widely in their susceptibility to attack by the chrysanthemum gall midge.

TABLE 3. NUMBERS OF GALLS ON A RANGE OF CHRYSANTHEMUM VARIETIES

| Varieties | Mean Number Galls per Leaf-sample (n) | Mean of log (n + 1) | Varieties | Mean Number Galls per Leaf-sample (n) | Mean of log (n + 1) |
|---|---|---|---|---|---|
| *C. leucanthemum* | 0 | 0 | Avondale Yellow | 50.0 | 3.75 |
| Chartreuse Rialgar | 4.5 | 0.48 | Red Cavell | 44.7 | 3.83 |
| Dulcina | 2.5 | 0.59 | Churinga | 40.5 | 3.85 |
| Frances | 6.1 | 0.71 | The Lion | 46.1 | 3.93 |
| P.B. Dickenson | 12.2 | 1.14 | Rose Terrace | 42.2 | 3.96 |
| Velvet | 7.5 | 1.35 | Ernest Hounsell | 38.0 | 4.12 |
| Greta | 12.4 | 1.71 | Wheatley's Pink | 62.3 | 4.21 |
| Janet | 26.7 | 2.03 | Pamela Vesty | 66.3 | 4.28 |
| Golden Bronze Button | 16.7 | 2.17 | Mrs. G. Waring | 55.3 | 4.31 |
| Dr. Parah | 20.1 | 2.35 | Cliveden* | 56.2 | 4.32 |
| Abundance | 17.7 | 2.42 | Malta | 49.5 | 4.41 |
| Madeleine | 28.3 | 2.59 | Apple Blossom | 65.3 | 4.51 |
| Coronation Pink | 33.8 | 2.69 | Elizabeth | 51.8 | 4.55 |
| Reo | 33.7 | 2.75 | Mrs. Lloydd | 52.0 | 4.67 |
| Afterglow | 35.3 | 2.97 | Golden Harvest | 84.3 | 4.79 |
| Royal | 35.8 | 2.99 | Desert Gold | 61.0 | 5.19 |
| New Guinea | 40.0 | 3.21 | Imperial Yellow | 62.1 | 5.19 |
| Amaranth | 40.0 | 3.27 | Wheatley's White | 68.3 | 5.21 |
| Bronze Tokio | 38.5 | 3.63 | Lily Gray | 79.0 | 5.25 |
| Ethel Ruderson | 43.8 | 3.67 | Lesma Day | 60.8 | 5.39 |
| Harbinger* | 42.4 | 3.69 | Mrs. W. Duckham | 81.9 | 5.48 |
| Mons Molin | 33.7 | 3.69 | Venice | 98.2 | 5.58 |
| | | | Difference for Significance at | 5% | 1.36 |
| | | | at | 1% | 1.78 |

* These two varieties are similar. It is possible that the two names apply to one variety only.

## CONCLUSIONS

Parathion at a concentration of either 0.025% or 0.0125%, when applied once a week, did not entirely prevent infestation, and some galls formed. It did, however, kill all midge larvae before the life-cycle was completed, thus checking the infestation. Where plants were already infested, control was gained when they were sprayed once a week with parathion. Parathion can, therefore, be recommended at all times for the control of chrysanthemum gall midge.

Other insecticides tested gave inadequate control except that nicotine sulphate, at a concenration of 0.1%, applied once a week to uninfested plants, gave partial protection. The control gained with nicotine sulphate would not justify its recommendation were it not for the fact that many home gardners are loath to use parathion because of its very high toxicity to man. Where this condition applies, the use of nicotine sulphate can be recommended as a preventive measure.

The existence of varietal resistance in cultivated chrysanthemums is shown, the varieties tested having a wide range of resistance. It appears that judicious selection of varieties would assist in control of gall midge.

Acknowledgements

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# RIPE SPOT OF APPLES IN NEW ZEALAND

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**Summary**

In the Nelson district, two fungi, *Gloeosporium perennans* and *G. album* both cause a storage rot of apples widely known as "ripe spot." *G. perennans* is a common stem parasite on apple trees, but *G. album* has been identified on stem cankers only twice. Thus, while stem infection is probably the main source of widespread fruit rot caused by *G. perennans,* it is still not clear how *G. album* perpetuates itself in sufficient quantity to be a fruit rotting pathogen of equal importance to *G. perennans.*

## Introduction

Although Taylor and Brien (1943) reserved the name "ripe spot" for the disease of apples caused by *Neofabraea malicorticis* and separated three similar fungus diseases from ripe spot by their symptoms on fruit, in general practice in New Zealand "ripe spot" has come to mean almost any circular rot on apples. Some orchardists, however, separate "bitter rot", caused by *Glomerella cingulata* on unpicked fruit, from "ripe spot" caused by other fungi on stored fruit. According to experience in England (Wilkinson, 1943) and in North America (Kienholz, 1939) there are four similar fungi all causing apple rots which cannot be distinguished by lesion symptoms alone. These fungi are as follows:

| Perfect stage | | Imperfect stage on apple fruits |
|---|---|---|
| *Glomerella cingulata* (Stonem.) Spauld. & von Schrenk. | : | *Gloeosporium fructigenum* Berk. |
| *Neofabraea malicorticis* (Cordley) Jackson | : | *Gloeosporium malicorticis* Cordley |
| *Neofabraea perennans* (Z. & C.) Kienholz | : | *Gloeosporium perennans* Z. & C. |
| Stage not known | : | *Gloeosporium album* Osterw. |

*Gloeosporium fructigenum* causes considerable wastage of fruit in New Zealand stores, and lesions on stored fruit caused by this fungus can rarely be distinguished macroscopically from those caused by other *Gloeosporium* species. However there is an obvious distinction between *G. fructigenum,* which can readily infect immature fruit on the tree as well as ripe fruit and apples in store, and the other species of *Gloeosporium* which are rarely noticed in the orchard but which cause serious losses in stored fruit. In the present paper the term "ripe spot" is used, therefore, for fruit rots caused by any of the species of *Gloeosporium* except *G. fructigenum.*

Because of the indifferent success of ripe-spot spraying programmes used in New Zealand in recent years, the disease is being reinvestigated. The first necessity was for a better understanding of the taxonomy and life history of the fungi involved, and this paper is concerned with those

aspects. Most of the work is being done in the Nelson district where the problem is generally regarded as being more important than in other provinces.

### Biology of the Diseases

In Europe and North America, the fungi causing ripe spot of apple fruits also produce, in varying degree, branch cankers on apple trees. In New Zealand, branch cankers caused by *Gloeosporium* spp. have not previously attracted attention although ripe spot on stored apples has been an important cause of fruit loss for several years. At the outset, therefore, an extensive search of trees was made in Nelson for stem cankers caused by *Gloeosporium* spp.

*Photo: J. A. Robinson*

Fig. 1.—Twig canker caused by *Gloesosporium perennans* at pruning cut. Openings on the canker surface are above acervuli. (x 3)

Branch cankers of *G. perennans* were found to be widespread throughout the district, particularly on the Sturmer variety. They are most common at pruning cuts (Fig. 1) and damaged fruit spurs, but also occur frequently at sites of woolly-aphis damage. Cankers were occasionally found on leaders and about the crown, where they were often larger than those on the smaller twigs. On leaders they sometimes extended to a length of about 15 cm. compared with a maximum of about 1 cm. on twigs. *G. perennans* was also recovered from 18 of 24 "tattoo cankers" on branches of Delicious, but inoculations of the isolates to clean branches produced cankers of the normal *G. perennans* type. Evidently, "tattoo cankers", like other forms of bark injury, provide an entry for *G. perennans*.

Of several hundred stem cankers examined, only two caused by a *Gloeosporium* species with curved spores were found. One, a small lesion at an old pruning cut on Sturmer, was producing conidia in mid May. The other canker, measuring 4.5 × 2 cm., was on a Sturmer leader and was bearing fresh conidia in mid October.

On branch cankers caused by *G. perennans,* fresh conidia have been found from October until May, but they are more plentiful in spring and autumn than in midsummer. Corke (1956) showed that, in England, inoculation of stem wounds with conidia of *G. perennans* was most successful in late autumn or early winter and moderately successful in spring. In New Zealand, these susceptible periods coincide with conidial production from branch cankers, and coincide also with the commencement and completion of winter pruning. This would explain the general prevalence of cankers at pruning cuts observed in Nelson.

In an experiment in Nelson, 50 wounds on twigs of Delicious were inoculated with apple tissue infected by *G. perennans* on 28 September 1955. By 25 October, cankers were well advanced at all inoculated wounds, and on a few cankers acervuli were producing conidia. Although the cankers became callused off during November and made no further growth, conidia were still being produced on 18 April 1956. Obviously, branch cankers resulting from spring infections will provide conidia to infect the fruit crop of the same growing season.

Both species of *Gloeosporium* found on stem cankers were also found to infect fruit, causing ripe spots. The ripe spots produced by the two species are identical, and the species responsible for any particular spot can only be identified after acervuli have been produced. In contrast to what might have been expected from their relative prevalence in stem cankers, both species appear to be equally common on stored fruit in Nelson.

Ripe spots on fruit have been found occurring naturally on the following varieties: Delicious, Dougherty, Dunn's Favourite, Granny Smith, Jonathan, Rokewood, Statesman, and Sturmer. It is possible that no variety is immune to the disease. Lesions on apples are circular, slightly sunken spots that enlarge slowly up to 5 cm., or even more, in diameter (Figs. 2, 3). The surface colour varies according to the colour of the apple. On Dunn's Favourite, a yellowish apple, spots are often yellow with a pale-brown margin. On Jonathan and Dougherty, which are red, spots are usually of a uniform deep-brown colour. On Sturmer and Delicious, lesions on blush faces tend to be uniformly brown while those on less highly coloured parts may have a pale-brown or yellow centre with a darker-brown margin. Rotted tissue below the surface is spongy, rather dry, and its colour varies with the surface colour from yellow to brown.

Acervuli are not usually produced on apples until the lesions have reached a diameter of about 1 cm. They usually appear first near the centre of the lesion and later become scattered more or less irregularly, though sometimes they show a tendency toward concentric zonation. Only when conidia have been produced can it be determined which of the two species is responsible for any particular lesion.

Ripe spot is regarded generally as a storage disorder and usually takes three or four months to develop in cool store. However, in 1955, Delicious apples picked in mid March and kept in a warm packing shed had well grown lesions less than three weeks later. In this case the organism responsible was *G. perennans.*

Although ripe spot predominantly affects apples after picking, *G. perennans* can make an entry into immature fruit at points of damage

*Photo: J. W. Endt*

Fig. 2.—Ripe spots caused by *Glocosporium perennans* on Sturmer apples, showing the size a single lesion can reach on fruit held for several months in cool storage. These apples were apparently clean when they entered store.

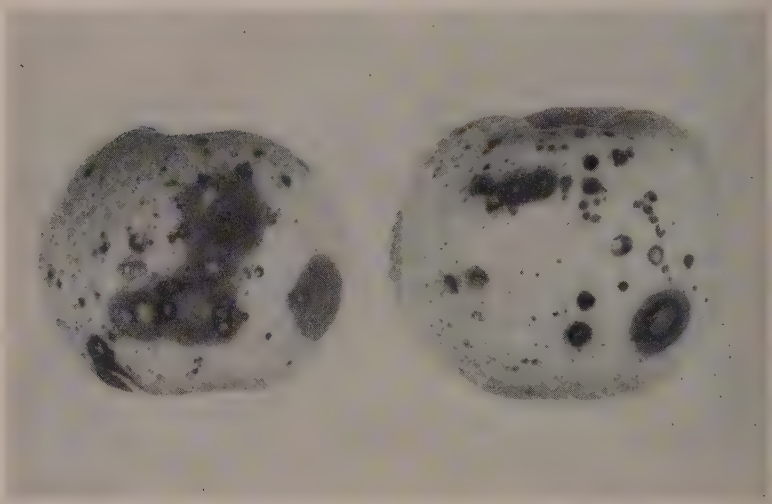

*Photo: J. W. Endt*

Fig. 3.—Ripe spots and lenticel spots on Sturmer apples which had been left on the tree 8 weeks after the last day on which the variety was accepted for export.

such as codling moth tunnels and limb rubs, and develop lesions while the fruit is still on the tree. One instance was found of a Dunn's Favourite apple on which acervuli and conidia were already present by picking time. In packed fruit held in cool store, the earliest lesions to develop are also associated with damage. As well as insect injury, common entry points are torn flesh caused by accidental removal of the stalk at picking, and stem punctures.

As the name implies, the most serious outbreaks of ripe spot in stored fruit are on lines which were ripest on entering store. It is widely recognized that fruit which has developed lenticel spots, a sign of advanced maturity, before it is put into cool store will be more readily affected by ripe spot than clean fruit, but it must be pointed out that ripe spot is not an inevitable consequence of lenticel spotting. Whether or not a lenticel spot will develop into a ripe spot depends on whether or not there are *Gloeosporium* conidia present to infect it. Lenticel spots, like other points of damage, provide good entrance for the fungi. Unfortunately there is no ready way of recognizing the difference, at harvest, between infected and uninfected lenticel spots, or between these and other young ripe spots. Both *Gloeosporium* spp. can infect fruit which is free from lenticel spots, and, as Edney (1956) has pointed out for *G. perennans,* susceptibility to attack through undamaged lenticels increases with fruit maturity.

It was observed in 1955 that, on fallen fruit of the early-maturing variety Monarch, conidia were being produced by the third week in March on ripe spots caused by both species of *Gloeosporium.* At that date several major varieties such as Jonathan, Sturmer, Statesman, and Dougherty were still to be picked. Obviously, windfallen fruit of early-ripening varieties can provide conidia to infect later-maturing apples. However, in a normal commercial orchard the chances of infection being spread by fruit, either to branches or to other fruit, are probably not great. Usually each variety is picked well ahead of maturity to conform to export requirements so that there is no opportunity for apples to ripen and fall. Provided also that control of black spot and insect pests has been satisfactory (as is generally the case), the amount of fruit discarded in the orchard by pickers will not be significant.

It appears, therefore, that although ripe spot on apple fruits is the most important feature economically in the biology of the two *Gloeosporium* species, infection of fruit has only minor significance in their life history. *G. perennans* can perpetuate itself in branch cankers and from them provide conidia which do not usually produce ripe spots on fruit until the apples are removed from the orchard. The fact that the other *Gloeosporium* sp., like *G. perennans,* is rarely found sporing on fruit in the orchard, and is also uncommon as a branch parasite on apple, suggests that, like *Glomerella cingulata,* it may have a range of alternative hosts.

## Taxonomy of the Fungi

In 1932, Brien identified and described *Gloeosporium perennans* as the causal organism of a storage disease reported by Cunningham (1925) as "Delicious spot". Brien (1934) later recorded *Neofabraea malicorticis* on stored apples, and in 1943 Taylor and Brien described a fruit-rotting *Gloeosporium* species with curved spores as *Neofabraea*

*malicorticis*, and named the disease caused by it "ripe spot". Neither species was recorded as causing naturally occurring cankers on branches, and descriptions were made from the fungi as they occurred on fruit. Kienholz (1939) points out that the main difference between *Neofabraea malicorticis* and *N. perennans* is in their pathogenicity and subsequent canker formation on twigs and branches. He found that the two species could not be distinguished on fruit rots alone since conidia of both species on apple lesions are of the *G. perennans* type.

The present study shows that *G. perennans* is a branch and fruit parasite in New Zealand as it is in England (Wilkinson, 1945). The species of *Gloeosporium* with curved spores, which is a rare branch parasite, though widespread on fruit, is considered to fit Osterwalder's (1907) *Gloeosporium album*, as interpreted also by Wilkinson (1943). Since stem cankers typical of *N. malicorticis* have not been found in Nelson, it is likely that the species of *Gloeosporium* described by Taylor and Brien as *N. malicorticis* was, in fact, *G. album*.

The main morphological features of the two species in Nelson are as follows:—

*Gloeosporium perennans* Z. & C.

Acervuli erumpent, cream-coloured, turning dark brown with age on stem cankers, 250–430 $\mu$ in diameter on stem cankers, 250–1,000 $\mu$ in diameter on fruit lesions. Conidiophores hyaline, septate, usually branched, with conidia borne singly at tips. Conidia in mass forming a cream-coloured ooze. Conidia hyaline, non-septate, cylindrical, usually slightly pointed at one end, 6.8–12 $\mu$ × 1.7–3.4 $\mu$ (av. 9 × 2 $\mu$) on stems, 5–15.3 $\mu$ × 1–3.4 $\mu$ (av. 10.4 × 2 $\mu$) on fruit.

*Gloeosporium album* Osterw.

Acervuli erumpent, cream-coloured, similar in size to *G. perennans*. Conidiophores hyaline, septate, usually branched, with conidia borne singly at tips. Conidia in mass forming a cream-coloured ooze. Conidia hyaline, non-septate or rarely one-septate, allantoid, usually slightly pointed at one end, 13.6–18.7 $\mu$ × 1.7–2.5 $\mu$ (av. 15.8 × 1.7 $\mu$) on stems, 10.2–20.4 $\mu$ × 1.7–2.5 $\mu$ (av. 15.8 × 1.9 $\mu$) on fruit.

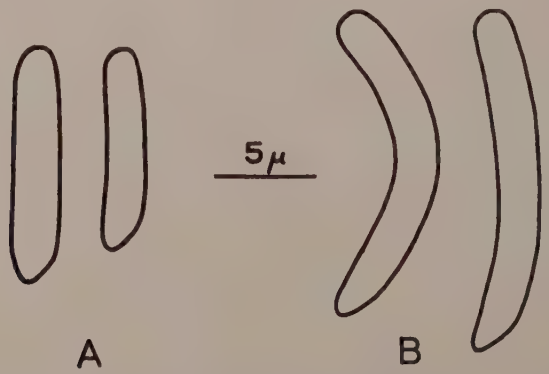


Fig. 4.—Conidial types. A. *Gloeosporium perennans*. B. *G. album*.

The perfect stages of these species have not been found in New Zealand. Conidia typical of the two fungi are shown in Fig. 4.

In the original descriptions of the two species, Zeller and Childs (1925) give conidial measurements of *G. perennans* as 12–20 $\mu$ × 4–6 $\mu$ with secondary conidia 3–10 $\mu$ × 1–2 $\mu$, while Osterwalder (1907) gives those of *G. album* as ca. 24 $\mu$ (seldom more than 26.8 $\mu$) × ca. 3 $\mu$. Although the conidia described above in New Zealand are rather smaller than those attributed to both species originally, the two New Zealand fungi come within the limits now accepted of *G. perennans* and *G. album*.

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# BREEDING SYSTEMS IN SOME NEW ZEALAND GRASSES

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**Summary**

The breeding system of twelve species from four tribes of the indigenous grasses has been investigated.

## Introduction

In earlier papers (Connor and Cook 1952, Connor 1954, Connor and Cook, 1955) the breeding systems of the indigenous grass species *Dichelachne crinita, Agropyron scabrum, A. kirkii, A. tenue, A. enysii,* and *Festuca novae-zelandiae* were discussed. The purpose of this paper is to fulfil the promise of further investigation on *Dichelachne crinita,* and to detail results from attempts to determine the breeding systems of other indigenous species. The purposes in examining the breeding system of these native grasses are (a) to determine the method of reproduction, (b) to provide basic data for work on population studies, and in this way (c) to provide information to assist taxonomists in revisions, (d) to provide data for proposed work on the genetics of incompatibility in selected species.

In all the trials reported here no attempt has been made to assess the extent of seed setting under self- or open-pollination. Generalized observations such as "No seed set", or "No $S_1$ progeny obtained" have been the only ones made. Emphasis has been placed on condition, vigour, height, and number of culms of inbred progenies compared with open-pollinated ones, because inbreeding depression if it is present will undoubtedly show up in one or more of these features. In these experiments no tests for apomixis have been attempted, nor has there been any emasculation or controlled cross-pollination.

The observations made in this paper on the breeding systems of native grasses bring the total number investigated to 16, which at an estimate is less than 10% of the indigenous grasses. Some larger genera, e.g. *Danthonia,* have not been examined at all, while in *Poa,* the largest genus of native Gramineae, only three species have been examined.

## Materials and Methods

Plants of all species have been grown in the nursery either from seed collected in the wild, or as wildings transferred into culture. All self-pollinations have been made using the method described by Connor and Cook (1952). Where there has been an inbred generation sufficiently large to warrant planting in a trial suitable for statistical analyses, randomized plots with inbred and open-pollinated control plants have been laid down.

## Results

### Tribe Festuceae

*Festuca novae-zelandiae* (Hack.) Cockayne. The seed from the two selfed plants from Omarama mentioned by Connor and Cook

(1955) yielded 45 $S_1$ plants for a trial which was laid down in September 1955. None of the plants, either $S_1$ or open-pollinated, flowered during 1955–56 season, and the previously reported inbreeding depression in one-year-old $S_1$ plants is again noted. A test designed to show the effect of one generation of out-breeding after one generation of selfing, though in its first year, indicates that full vigour is restored. The detailed results of these two trials will be published after the plants have matured.

*Poa breviglumis* Hook. f. The plants of this perennial species were originally from either seed or plants from Campbell Island. One plant raised from seed was selfed in 1952–53 season. A small $S_1$ progeny was raised as was also a small open-pollinated lot. There were no degenerate plants among the $S_1$.

*Poa caespitosa* Sprengel. A perennial grass common to New Zealand and Australia. The material used in these trials was collected at Cromwell. In the season 1952–53, a single plant was selfed, but yielded no $S_1$ progeny. In the following season a plant of the same lot was selfed and yielded 3 $S_1$ plants, which when compared with plants from open-pollination showed every evidence of inbreeding depression.

*Poa colensoi* Hook. f. This perennial grass is indigenous to New Zealand. Between 1950–51 and 1954–55 8 plants derived from collections from Roxburgh, Alexandra, Omarama, and Molesworth have been self-pollinated, but in not one case has an $S_1$ progeny been obtained.

Of the plants of the three *Poa* species tested those of *P. colensoi* were self-sterile, and those of *P. caespitosa* inefficiently self-fertile. *P. breviglumis* is in all probability a self-fertilizing species, but as apomixis is not uncommon in *Poa* this method of reproduction cannot be ruled out, and appropriate tests will be made. Clausen *et al.* (1952) state that *P. caespitosa* of Australian origin, judged by its variability following self-pollination, is an outbreeder. Triplett and Clausen (1954) report that *P. caespitosa* from Canberra, Australia, is a sexual species with 2n = *ca* 56 (octoploid), while material from the Awatere Valley, Marlborough, collected at 500 ft. by Miss L. B. Moore ". . . had chromosome numbers ranging between the 13- and 14-ploid levels, 2n = *ca* 90–100." Barclay (1950) concludes from fertility studies, germination tests, comparison of inbred and open-pollinated generations, and progeny tests that ". . . *Poa caespitosa* may be regarded as being in all probability a naturally cross-fertilized species." His evidence warrants the deletion of the words "in all probability". Barclay's experiments were considerably more varied and more numerous than those reported in this paper. The few results obtained in 1955–56 agree with those of Barclay.

*Puccinellia fasciculata* (Torr.) Bicknell. This perennial species is found in North America, Europe, and South Africa, but the two varieties, *novazelandica* Allan et Jansen, and *caespitosa* Allan et Jansen, are considered to be indigenous. Material of var. *novazelandica* was raised from seed collected from the estuary of Mill Creek, Stewart Island, and that of var. *caespitosa* was collected near Alexandra and transplanted into the nursery. When both varieties are grown in cultivation at Botany Division Gardens, Christchurch, var. *novazelandica* does not become as tall as the herbarium specimens from the parent site indicate,

and var. *caespitosa* becomes taller than it is in its typical saline sites in Otago. The two varieties are remarkably alike in cultivation, though as yet it is not possible to say whether the mat-forming habit of var. *caespitosa* will develop under cultivation, nor is it known whether the two varieties cross in the gardens.

*P. fasciculata* var. *caespitosa.* A single plant was selfed in 1953–54 season and yielded sufficient $S_1$ plants for a small trial. This trial suffered from over-hoeing and a very few plants remained. No depression could be seen in these. In the same season a plant was selfed to produce another $S_1$ generation. The resulting $S_1$ progeny was planted, but it was not possible to examine it in detail. There was however no noticeable gross difference between the $S_1$ and the open-pollinated generation. In both instances ample seed appeared to be set under selfing as is the case with var. *novazelandica.*

*P. fasciculata* var. *novazelandica.* One plant was selfed in 1951–52 and produced sufficient selfed seed to raise an $S_1$ generation for trial. The results from the recordings are analysed in Table 1. From this $S_1$, 2 plants were selfed in 1952–53 and produced $S_2$ generations which were planted separately in two orthodox adjacent randomized plots. In both plots open-pollinated plants raised from seed from control plants in the 1952–53 trial were used as controls. The results are summarized in Table 1. In both years, in addition to the measurement of maximum culm height and the count of the number of culms per plant, the length of the longest branch in the bottom fascicle of the panicle was measured on 3 panicles per plant for all plants in the trials. This character was found to be correlated with plant height ($r = 0.7$), and for this reason details of these measurements are not presented.

TABLE 1. MEAN HEIGHT AND MEAN CULM NUMBER IN *P. fasciculata* var. *novazelandica*

| Season | 1952–53 | | 1953–54 | | | |
|---|---|---|---|---|---|---|
| Generation | $S_1$ | Open-pollinated | $S_2$ | Open-pollinated | $S_2$ | Open-pollinated |
| Mean ht. (cm.) | 33.34 | 35.21 | 43.07** | 38.37 | 29.27** | 26.36 |
| Mean No. culms | 11.23 | 15.69** | 25.76** | 18.84 | 13.94* | 11.36 |

** Significant at 1% level

* Significant at 5% level.

There was a highly significant difference for number of culms per plant between open-pollinated and $S_1$ progenies (Table 1), but this difference was reversed in the two $S_2$ generation trials. We cannot conclude that inbreeding has had any adverse effects. In the same variety in 1953–54, $S_2$ plants from two separate $S_1$ plants were tested against open-pollinated control plants of common origin. The two trials, each of about 180 maturing plants, were planted one beside the other on the same day, but one trial gave a very different mean height and mean number of culms per plant from the other. The change

between trials was immediate and clearly visible. There appears to be no simple explanation for this marked difference but, be the cause what it may, the difference between the two trials in no way affects the conclusion, which can be drawn from either trial, that inbreeding has no deleterious effect on the species.

In the 1953–54 season, three plants were selfed for an $S_3$ generation, and a trial was planted in September 1954. This trial received the same treatment as that for var. *caespitosa* and very few plants survived.

The two varieties of *P. fasciculata* are self-fertile.

Tribe Hordeeae

*Cockaynea gracilis* (Hook. f.) Zotov. This perennial grass is found only in New Zealand. Plants were raised from seed from a single plant growing in cultivation in Hutt Valley, originally from Hauhangaroa Range west of Lake Taupo. In the season 1952–53 one plant was selfed and set abundant seed. An $S_2$ generation was produced in the season 1953–54, but no observations were made on the plants. The seed-set appears to be high. Of the two species recognised in New Zealand only *C. gracilis* has received a preliminary investigation and *C. laevis* is now in culture.

Tribe Aveneae

*Deschampsia caespitosa* (L.) Beauv. This perennial species is found in North America, Europe, Australia, New Zealand, Africa, and South America. Plants used here were raised from seed collected from south Canterbury, and one of these was selfed in 1951–52 season. An $S_1$ progeny of 17 plants was raised and planted in a trial with open-pollinated control plants. No measurements were made, but there appeared to be no difference between the two generations. The trial, and 900 plants in a plot 6 chains away, deteriorated in condition and finally died off during June, July, and August of 1954, when all plants were just over 2 years old. Whether this represents the lifespan of *D. caespitosa* in cultivation or the selective action of some fungal or animal attack is not known. Suffice it to say that no other of a dozen species of grass growing in the same nursery at the same time suffered in the same way. A single plant from the Kaimanawa Mts. was selfed in 1953–54, but yielded no $S_1$ progeny. In 1954–55 the plant was divided into 3, potted, and kept in a frame. This clone, the only material of *D. caespitosa* in the garden, in 1955–56 set a quantity of clean viable seed from which 420 plants have been raised. Among these were 2 albino seedlings which died. It will be difficult to determine whether or not inbreeding has had any effect on this $S_1$ as there are no plants available as controls.

Beddows (1931) reports "*D. flexuosa* was found by Körnicke to be like *D. caespitosa*, fully sterile.", but Beddows found that the *D. flexuosa* material he examined, though not completely self-sterile was low in self-fertility, and $S_1$ seed was low in germination.

Nygren (1949) states that *D. caespitosa* is an allogamous species in which vivipary has been recorded. Vivipary was induced by Nygren (1949), while Lawrence (1945) observed that non-viviparous Swedish and Finnish biotypes became viviparous when cultivated in California. In the trial reported here, plants were growing about 130 miles north

and 350 miles south of the source at which seed was collected, a distance that is probably nowhere near great enough to affect day length or growth rhythm in such a way that vivipary would be induced. No bulbils were observed on the plant bagged, and it is assumed that seed was set by the normal sexual process in 1951–52 season. Normal seed was set on the Kaimanawa clone. Herbarium specimens of indigenous collections have been examined and these reveal no bulbils. The $S_1$ and open-pollinated plants in the small trial planted out were not visibly different in vigour. The total wiping out or natural death of all *D. caespitosa* in the second season of what was believed to be a long-lived perennial precluded measurements at maturity. *D. caespitosa* in New Zealand appears to be a self-fertile species.

*Trisetum antarcticum* Trin. Seed of this indigenous perennial species was collected from Omarama, North Otago. Among the plants raised one was selfed in 1953–54, but no seed was set.

*Trisetum youngii* Hook. f. Two plants of this species have been selfed, one in 1951–52 and one in 1952–53; in neither case was seed set.

Tribe Agrostideae

*Deyeuxia avenoides* Buch. Two collections of this indigenous perennial grass have been made, both in Hutt Valley, Wellington. One plant selfed in 1953–54 yielded an $S_1$ progeny but insufficient for a satisfactory trial. Another plant was selfed in 1952–53 and yielded $S_1$ progeny for a very small trial. There were neither visible nor statistically significant differences in plant height, number of culms, or panicle length, between the two generations. In 1953–54, one $S_1$ plant was selfed but produced only one $S_2$ plant. In 1954–55, an $S_1$ plant was selfed and produced an $S_2$ generation which was large enough to plant out in a trial. The results from this trial are presented in Table 2. There were no statistically significant differences between selfed and open-pollinated progenies.

TABLE 2. Height and Number of Culms in Open-pollinated and Second Inbred Generations of *D. avenoides*

| Generation | Mean ht. (cm.) | Standard Deviation | Mean No. Culms | Standard Deviation | No. of Plants |
|---|---|---|---|---|---|
| Open-pollinated | 54.1 ± 1.97 | 10.6 | 12.03 ± 1.34 | 7.21 | 29 |
| Self-pollinated | 52.2 ± 1.88 | 10.12 | 8.83 ± 1.15 | 6.19 | 29 |

*Deyeuxia forsteri* (Roem. et Schult.) Kunth. Seed for *D. forsteri* I was collected from Porters Pass, Canterbury, at 3,100 ft. and seed for *D. forsteri* II was collected from Carters Saddle, Molesworth, inland Marlborough at about 4,000 ft. When in cultivation, *D. forsteri* I is a green-leaved perennial with ascending branches in the bottom whorls of the panicles, and *D. forsteri* II is a purple-leaved perennial with very reflexed branches in the bottom whorls of the panicles; I flowers earlier than II, but the two forms are synchronous for a time.

*D. forsteri* I. In 1952–53, a single plant was selfed and produced an $S_1$ progeny. No measurements were made but there were no visible differences between the two generations. A single plant from this $S_1$ yielded an $S_2$ which was planted out in a randomized block with open-pollinated plants as controls. All plants in this trial were scored for vigour and rated 5–1, 5 being the most vigorous and 1 the least vigorous. The results are presented in Table 3. Seven plants in each generation died between planting and scoring.

TABLE 3. NUMBER OF PLANTS IN $S_2$ AND OPEN-POLLINATED GENERATIONS OF *D. forsteri* I SCORED FOR VIGOUR 1954–55

| Score | No. Plants | |
|---|---|---|
| | $S_2$ | O-P |
| 5 | 2 | 2 |
| 4 | 2 | 3 |
| 3 | 4 | 1 |
| 2 | 1 | 4 |
| 1 | 4 | 3 |
| Total Number of Plants | 13 | 13 |
| No. Planted | 20 | 20 |

In the season 1954–55, $S_2$, $S_1$, and open-pollinated plants were selfed to produce $S_3$, $S_2$, and $S_1$ generations. Of these there were insufficient plants of $S_1$ for a trial. The results from this trial, which experienced an excessively dry season after planting out, are summarized in Table 4.

TABLE 4. SURVIVAL, FLOWERING, AND AVERAGE HEIGHT OF CULMS IN *D. forsteri* I 1955–56

| Generation | No. Planted | No. Survived | No. Flowered | Average Ht. Culms (cm.) |
|---|---|---|---|---|
| $S_3$ | 21 | 13 | 8 | 54.1 |
| $S_2$ | 21 | 10 | 3 | 58.0 |
| Open-pollinated | 21 | 14 | 10 | 50.0 |

A single plant of *D. forsteri* II was selfed in 1954–55 season, but yielded no $S_1$ progeny. Two plants selfed in 1956–57 season set seed.

In 1955–56 season, progenies from open-pollinated *D. forsteri* I and II plants which grew close together in 1954–55 were raised, and

TABLE 5. Localities, and Results from Statistical Analyses on Inbred and Open-pollinated Generations in *Dichelachne crinita*

| Collection No. | Locality | $S_1$ v. Open-pollinated | | | | $S_2$ v. Open-pollinated | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean Plant Ht. (cm.) | | Mean No. Culms | | Mean Plant Ht. (cm.) | | Mean No. Culms | |
| | | $S_1$ | O–P | $S_1$ | O–P | $S_2$ | O–P | $S_2$ | O–P |
| I | Porters Pass, Canterbury | 81.5 | 78.3 | 21.7 | 18.9 | 68.2 | 75.1 | 11.6 | 15.7 |
| II | Dry Creek, Canterbury | 88.5 | 89.6 | 11.4 | 11.3 | 71.8 | 84.1 | 7.8 | 13.9 |
| III | Craigieburn, Canterbury | 89.5** | 81.2 | 15.8 | 16.0 | 74.4 | 83.4 | 15.6 | 22.0 |
| IV | Lake Coleridge, Canterbury | 84.3 | 90.1** | 17.2 | 17.7 | 67.9 | 76.7 | 14.6 | 16.8 |
| V† | Roxburgh, Otago | 77.6 | 76.4 | 26.3 | 21.8 | 90.1 | 89.2 | 23.3 | 23.3 |
| VII | Dillon, Molesworth, Marlborough | 69.2 | 65.3 | 8.6 | 11.4 | 96.2 | 95.0 | 16.9 | 22.6* |
| VIII | Lake Camp, Canterbury | 73.2 | 72.8 | 15.4 | 10.0 | 97.6 | 95.0 | 23.7*** | 17.0 |
| IX | Lake Clearwater, Canterbury | 78.0 | 79.3 | 11.4 | 11.7 | 102.6 | 100.5 | 22.7 | 20.4 |
| X | Potts River, Canterbury | 60.1 | 69.1 | 7.0 | 5.5 | 115.2** | 104.2 | 17.4 | 15.6 |
| XI | Mt. Somers, Canterbury | 70.4 | 63.0 | 13.0 | 7.8 | 100.0 | 97.5 | 21.8 | 21.4 |
| XII | Omarama, North Otago | 68.0 | 78.0 | 7.2 | 10.0 | 85.0 | 84.3 | 14.3 | 13.6 |
| XIII | Omihi, North Canterbury | 46.9 | 75.3** | 3.4 | 5.6 | | | | |

† Results presented in 1952, recalculated and presented again for completeness.
* significant at 5% level
** ,, ,, 1% ,,
*** ,, ,, 0.1% ,,

while there is some little evidence that cross-pollination has occurred, there is not enough known of the expression of the characters to enable one to assess its extent.

Both *D. avenoides* and *D. forsteri* I were quite self-fertile, and the progenies raised from self- and open-pollination did not differ. There are no data yet on the selfed seed of *D. forsteri* II. Self-fertilization may not be the norm in nature, as may to some extent be suspected from the results of raising progenies from contiguous plants of *D. forsteri* I and II.

*Dichelachne crinita* (Linn. f.) Hook. f.

Plants studied in this perennial species, which is also found in Australia, were raised from seed collected in the wild. Localities where seed was collected, and the results from statistical analyses of the measurements and counts made are reported in Table 5. Thirty-three plants were selfed for these trials. One $S_3$ generation was raised, viz. Collection No. V, in which 15 pairs of plants were compared for plant height, and 11 pairs for number of culms per plant. The mean height for $S_3$ was 59.3 cm. and for open-pollinated plants 49.73 cm., the difference being non-significant, while a non-significant difference for culm number was also found where the mean number of culms per plant was 13.2 for $S_3$, and 8.3 for open-pollination. In addition to the measurements reported above, in the 1953–54 season panicle length of 3 panicles per plant for all plants in $S_1$ and open-pollinated generations for collection Nos. I–IV was measured. This was found to be correlated with plant height ($r = 0.69$), and for this reason the statistical analyses on panicle length are not reported here in detail. Collection No. XIII showed a marked reduction in plant height in $S_1$, but no $S_2$ generation was produced as this collection was overlooked.

The results obtained from the seasons 1953–54, 1954–55, 1955–56 are in agreement with those previously reported. In all it seems that the species is a self-fertilizing one in nature.

## DISCUSSION

With self-fertile species it is difficult, without marker genes, to determine whether or not self-fertilization is the norm in nature. Amongst the self-fertile species discussed here, Cockayne and Allan (1934) list as wild hybrids the following, *Deyeuxia avenoides* × *D. quadriseta* (doubtful), *D. billardieri* × *D. forsteri* (doubtful), *D. forsteri* × *D. pilosa, Dichelachne crinita* × *D. sciurea*. Such a list of hybrids need not mean that the species concerned are to be considered as allogamous, for interspecific hybrization between autogamous species is well established. In the case of *Deyeuxia forsteri* where two collections with good genetic markers grew close enough together for cross pollination there is a little evidence for cross pollination.

As both *Festuca novae-zelandiae* and *Poa caespitosa* are self-fertile to a limited extent and produce degenerate $S_1$ progenies, the question arises whether self-fertilization is avoided in nature. In these species there is apparently no mechanism by which self-fertilization can be avoided, but there are no data available on the frequency with which selfing occurs. There are sites where plants of these species are so sparse

that selfing might be enforced. The low viability of seed from selfing and the reduced vigour of the plants would act against any major contribution to the populations of these species by plants from self-fertilized seed except perhaps in unusual circumstances. In *F. novae-zelandiae*, inbred plants in nature would, if cross pollinated by outbred plants, yield seed that would give rise to plants fully restored in vigour.

It is worth re-emphasizing that *Deschampsia caespitosa* (L,) Beauv. proved self-fertile in these trials although considered self-sterile in Europe.

In all species examined the flowers were chasmogamous.

## Conclusions

The results from the investigations on the breeding systems of the 12 species tested are summarized in Table 6.

TABLE 6. Fertility Classification of Species Examined
(Numbers of plants tested are in brackets)

| Self-fertile with Normal Selfed Progeny | Self-fertile but with Degenerate Selfed Progeny | Self-sterile |
|---|---|---|
| *Poa breviglumis* (1) | *Festuca novae-zelandiae* (11) | *Poa colensoi* (8) |
| *Puccinellia fasciculata* (8) | *Poa caespitosa* (2) | *Trisetum antarcticum* (1) |
| *Cockaynea gracilis* (3) | | *Trisetum youngii* (2) |
| *Deschampsia caespitosa* (3) | | |
| *Deyeuxia avenoides* (4) | | |
| *Deyeuxia forsteri* I (7) | | |
| *Deyeuxia forsteri* II (3)* | | |
| *Dichelachne crinita* (33) | | |

* Vigour of $S_1$ not known.

## Acknowledgements

Thanks are due to Mr. R. Leadbetter, Applied Mathematics Laboratory for statistical analyses presented in this text, and to Miss L. B. Moore and Messrs. A. P. Druce and G. A. Dunbar for seed and plants of various species.

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# EFFECT ON HONEY BEES OF METASYSTOX APPLIED FROM THE AIR AS A SPRAY TO CHOU MOELLIER*

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## Summary

Metasystox was applied from the air to 11 acres of chou moellier in flower, at a rate estimated to be 16 fl. oz. of Metasystox per acre. The spray was applied in the evening when no bees were flying. Before the application, it was established that bees from a nearby experimental apiary were collecting nectar and pollen extensively from the crop.

The Metasystox spray killed virtually all field bees within two days. It was shown that nectar in the chou moellier flowers was toxic to bees for five days after spraying. Bees appeared unable to collect pollen from the crop after spraying.

It was considered that all bumble bees visiting the crop were killed.

Metasystox should on no account be applied to plants with flowers attractive to bees. Such plants should be sprayed at least a fortnight before they flower.


## INTRODUCTION

Cruciferous crops grown for seed in New Zealand are prone to aphid infestation which reduces yield. In Canterbury, the centre of seed production, growers soon realized that the newer insecticides could be applied from the air to control these pests. But beekeeping also is highly developed in Canterbury which is one of New Zealand's best honey-producing areas. The main local source of nectar is white clover (*Trifolium repens*), but honey bees are greatly attracted by the flowers of brassica crops in the spring, and, while collecting nectar and pollen, perform an essential service as pollinators. So it was not surprising that the uncontrolled application of insecticides from the air resulted before long in bee mortality. In September 1955, heavy losses of bees occurred near Darfield through aerial dusting with lindane, at the rate of 8 lb. of a 6¼% dust per acre, of chou moellier in flower[1]. This resulted in the adoption of a system whereby permits, issued by Civil Aviation, were required for the application of insecticides from the air. Later, this method of control was replaced by one in which all firms applying insecticides from the air in Canterbury voluntarily agreed to seek the advice of the local Apiary Instructor before treating crops which might be attractive to bees. The application of insecticides from the ground is not controlled in any way, although it can be as dangerous to bees as aerial application.

The problem, therefore, is to find a satisfactory way of maintaining our beneficial insects and safeguarding the beekeeping industry. In this connection there is a strong obligation on the technical advisers of the beekeeping industry to assist the crop growers by conducting trials of newly developed insecticides with the aim of discovering ones which could be used to control pests effectively without harming bees. The trial of Metasystox now described was initiated with this end in view.

* Chou moellier = marrow-stem kale (*Brassica oleracea* L.)

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Metasystox is the proprietary brand name of a new systemic insecticide containing as active ingredient 50% W/W and 56% W/V of an 0, 0-dimethyl-thiophosphoric-0-(B-S-ethyl)-ethyl-ester, which consists of 30% of the P-O isomer and 70% of the P-S isomer ("Mixture 30–70") developed by Farbenfabriken Bayer, Leverkusen, Germany. It is one of the systemic insecticides, which are absorbed and translocated in the sap of plants, and which are particularly effective in controlling sucking insects such as aphids. The active ingredient of Metasystox is absorbed by plant tissues under normal conditions within two hours of application[2]. Metasystox is decomposed in the plant to harmless products, the rate at which this process occurs being influenced by the season and the rate of growth of the plant. It can thus be used on certain edible crops provided four to six weeks elapse between the final application and harvesting[3]. Unlike most systemics, Metasystox has a low mammalian toxicity and so can be applied without the special precautionary measures usually necessary for this group.

Farbenfabriken Bayer state that the use of Metasystox constitutes no hazard to bees provided it is applied correctly, i.e., the bees should not come into direct contact with the Metasystox wash. Plants sprayed in the evening can be settled on next day by bees without any harm being done to them. Should it be necessary to spray into the blossom, care must be taken to apply the Metasystox only in the evening after the bees have stopped flying. As long as this rule is strictly observed there will be no hazard to bees. Metasystox, when applied correctly, is quoted by the B.F.A., Celle, as being harmless to bees[4].

In a later report, Farbenfabriken Bayer describe field tests conducted to check the toxicity to bees of 0.1% Metasystox applied in three-litre volumes to two apple trees in full blossom. The trees were surrounded with wire-mesh tents in each of which 200 young and mature bees were placed in small protective cages with built-in comb boxes 48 hours before spraying. Most bees avoided the first tree after it had been sprayed at 1 p.m. in the afternoon. A knock-down effect was observed in the case of bees which did come in contact with the spray coating, and 28% died in 48 hours.

Bee mortality was negligible for 48 hours after the second tree had been sprayed at 7.30 p.m. in the evening. It is concluded that Metasystox is practically harmless if applied in the evening when bee flight is over[5]. However, these claims appeared to be based on inadequate evidence and the experiments cited were artificial and far removed from field conditions.

It seemed from the information available that Metasystox might be an efficient and safe systemic to use for the control of aphids in brassicas such as rape and chou moellier. If it could also be applied to brassicas in flower without harming honey bees, its use could be recommended without any fear of a repetition of the mortality caused by the application of lindane. Accordingly, the Department of Agriculture initiated a large-scale investigation to discover what effect Metasystox would have upon honey bees when sprayed from the air on a crop of chou moellier in flower. The Metasystox was applied in the evening, when no bees were flying, at the maximum concentration likely to be used in practice.

The Entomology Division, Department of Scientific and Industrial Research, Ashburton, was responsible for applying the Metasystox to the crop and studying its effect on aphid infestation. This aspect of the trial is covered in a separate paper.

## Experimental Area

The experimental area was situated near the mouth of the Hinds River on the farm of Mr. H. J. Carr. It was approximately 15 miles in a straight line from Ashburton in Canterbury.

The crop of chou moellier, approximately 11 acres in extent, was the only floral source in the area except for a little storksbill (*Erodium cicutarium*) from which the bees were observed to collect nectar and pollen. Bees also collected pollen from scattered patches of gorse and broom.

The chou moellier had been fenced for seed and was of uniform height except for one portion where the tops of plants had been eaten off by stock during the winter. These plants had recovered by the time of the experiment, although they remained somewhat stunted.

Eighteen hives of bees were moved to the experimental area on 24 September and placed outside the crop so that the prevailing wind

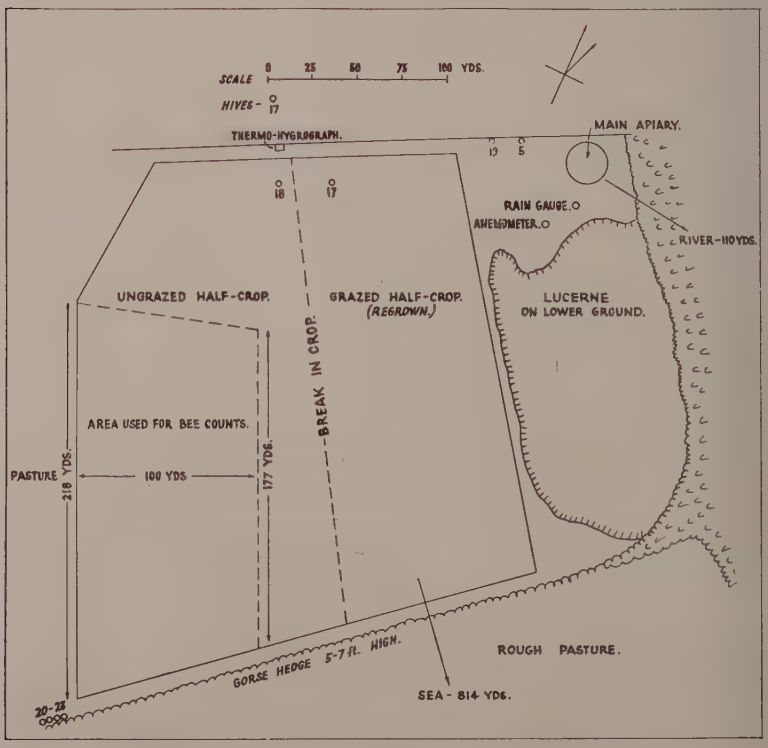


Fig. 1.—Plan of chou-moellier crop.

would prevent spray drifting over them. Before observations commenced, two of these hives (Nos. 17, 18) were moved right into the crop (Fig. 1). The layer of grass was removed in front of each hive to expose a smooth surface on which dead bees could be readily seen.

The experimental hives were of a strength which would be attained in an apiary managed by an experienced commercial beekeeper at the time and in the location of the experiment. They were three storied Langstroths with an average brood area of nine frames (both sides).

There was no other field of chou moellier in the district and, owing to the difficulty of preventing Metasystox drifting when applied from the air, it was not thought that the spray could be confined to half the field with any degree of accuracy. So no control crop was studied and the whole field was sprayed.

## EXPERIMENTAL PROCEDURE

### *Weather Observations*

A thermo-hygrograph and rain gauge were installed and daily readings made with a portable anemometer. Wind and other conditions were also noted (Fig. 2 and Table 1).

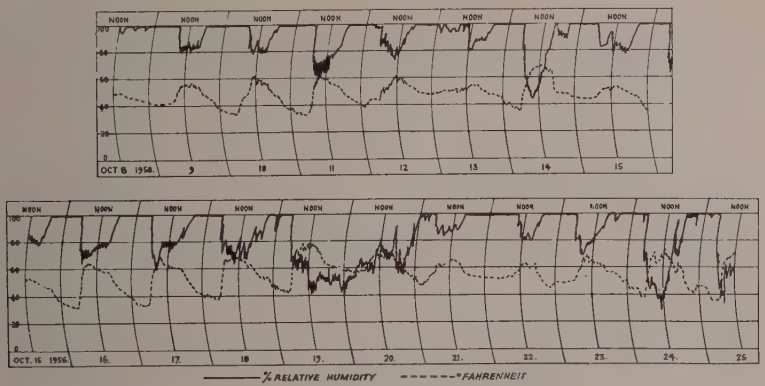


Fig. 2.—Thermo-hygrograph readings.

### *Application of Spray*

Metasystox emulsion was mixed with water to give a 1% concentration. Seven gallons of this dilution, containing 20 fl. oz. of Metasystox, was applied per acre from the air to the chou moellier crop.

The maximum rate of application recommended in Britain is 16 fl. oz. per acre[3]. The aim of the experiment was to study the effects of this maximum application upon bees and aphids. But at the time of spraying the wind speed varied from 5.5 to 9 m.p.h. and so an extra 4 fl. oz. of Metasystox per acre were applied to allow for spray drifting away from the crop. It is considered that the actual amount of spray which reached the crop was equivalent to approximately 16 fl. oz. of Metasystox per acre.

TABLE 1. WEATHER CONDITIONS AND GENERAL INFORMATION

| Date Oct. 1956 | Rainfall 24 hr. 10 a.m. | Wind | | | Weather | Bee Activity |
|---|---|---|---|---|---|---|
| | | Time of Reading | Velocity m.p.h. | Direction | | |
| 10 | Trace | 10 a.m.<br>2.30 p.m. | 3.3<br>9.7 | N.E. by E.<br>N.E. by E. | Cool winds, gusty. Overcast with sunny periods. | Short bursts coinciding bright periods. |
| 11 | Trace | 10.20 a.m.<br>11 a.m.<br>1.50 p.m. | 9<br>10.5<br>14.5 | N.E. by E.<br>N.E. by E.<br>E.N.E. | Overcast at times. Cool to cold wind increasing in strength after noon. | Good until 1.30 p.m. Declining to only slight activity by 3.30 p.m. |
| 12 | | 10 a.m.<br>noon<br>2.30 p.m. | 7.25<br>12.25<br>9.75 | N.E. by E.<br>N.E. by E.<br>E.N.E. | Bright, sunny, morning. Later overcast with cool winds, gusty. | Good until 2 p.m., easing later. |
| 13 | 0.11 | 10.30 a.m.<br>noon | 11.5<br>13.0 | S<br>S | Overcast, light showers, cold wind. | Nil. |
| 14 | Trace | 10.15 a.m.<br>noon<br>3 p.m.<br>4 p.m. | 9<br>10.25<br>8.25<br>8.33 | N.N.E.<br>N.N.E.<br>E.N.E.<br>E. | Light cloud, bright, sunny. Cool wind. | Maximum. |
| 15 | 0.12 | 11.15 a.m.<br>1.30 p.m.<br>3.15 p.m. | 8.33<br>5.5<br>6.25 | E.<br>E.N.E.<br>N.E. | Overcast, slight drizzle morning. Cool to cold wind. | No bees flying in morning. Slight activity 1 to 3 p.m. |
| 16 | Trace | 10 a.m.<br>noon<br>3.45 p.m.<br>6 p.m.<br>7 p.m. | 6<br>12.25<br>13<br>9.5<br>5.5 | E.<br>E.<br>E.<br>N.E.<br>N.N.E. | Light cloud, mainly fine, sunny conditions. Cool winds increasing in strength from 11 a.m. | Maximum until 3 p.m.; then easing and ceasing entirely about 5.30 p.m. |
| 17 | — | 10.15 a.m.<br>noon<br>3.15 p.m.<br>4.30 p.m. | 7.5<br>13.0<br>10.33<br>10.75 | E.<br>E.<br>E.<br>E. | Light cloud, cool wind. Bright, sunny, all day. | Should have been at maximum but rapidly declined and was almost negligible by afternoon. |
| 18 | — | 10.15 a.m.<br>12.15 p.m.<br>3.15 p.m. | 5.75<br>7<br>12.25 | S.S.E.<br>E.S.E.<br>E.N.E. | Light cloud, cool wind. Almost ideal for bee activity, bright, sunny. | Should have been at maximum but almost no bees on crop. |
| 19 | — | 10.30 a.m.<br>1 p.m.<br>1.45 p.m.<br>3.15 p.m. | 7.25<br>6.8<br>17.25<br>18.25 | E.S.E.<br>E.<br>W.N.W.<br>N.W. | Light cloud, bright, sunny. | Little although conditions ideal. |
| 20 | | 10.15 a.m.<br>1 p.m.<br>2.30 p.m.<br>4.45 p.m. | 8.25<br>9.75<br>5.5<br>6.25 | N.N.E.<br>S.S.W.<br>S.E.<br>E.S.E. | Warm, overcast, morning. Bright, sunny afternoon with about 30% light cloud. | Maximum hives capable of all day but field bees bring in mainly water and no pollen from crop. |
| 21 | Trace | 10.30 a.m.<br>noon<br>3 p.m.<br>3.30 p.m. | 12.5<br>12.5<br>13.5<br>12.75 | S.S.W.<br>S.<br>S.<br>S. | Morning overcast, about 80% cloud, cool wind. Afternoon, light cloud, bright, sunny, cold. | Fair considering weather conditions. |
| 22 | 0.02 | 11 a.m.<br>2.15 p.m.<br>3.30 p.m. | 4.75<br>5<br>8.25 | S.<br>E.N.E.<br>E.N.E. | Light wind morning 100% overcast to 2.30 p.m. Then breaks in cloud with warm sunny periods. | Fair, increasing to maximum by 2.30 p.m. |
| 23 | — | 10.30 a.m.<br>11.30 a.m. | 8.5<br>13.65 | E.N.E.<br>N.E. | Light cloud, cool, gusty. Bright, sunny, warm in sheltered places afternoon. | Maximum in morning decreasing slightly at noon. |
| 24 | — | 11.30 a.m. | 18 | N.N.W. | Light cloud; bright, sunny. | Maximum. |
| 25 | 0.01 | 10 a.m. | 7.5 | S. | Clear sky, bright, sunny, warm. | Maximum. |
| 31 | Not Recorded | 10.30 a.m.<br>12.30 a.m.<br>1.15 p.m. | 3.5<br>7.5<br>7.5 | | Bright sunshine. | Maximum. |

The spray was applied between 6.15 and 7 p.m. on 16 October. During the day, weather conditions had been good (Table 1) and there was maximum bee activity on the crop; but by 5.30 p.m. activity had ceased and all the bees were in their hives so none were exposed directly to the spray. The average temperature during spraying dropped rapidly from 50° to 46°F. (Fig. 2) and the humidity reached about 100%. During the night, the temperature dropped further to 32°F. but rapidly rose the following morning to 68°F., when the humidity was 58%. Weather conditions were ideal for bee activity on the day after spraying.

The low night temperatures typical for Canterbury at this time of the year would be expected to prevent rapid evaporation of unabsorbed spray from plants. The deposition of dew and liquid exuded by the plants would further tend to slow down evaporation. It was observed when walking through the crop at 10 a.m. on the morning following spraying that the plants were moist and smelt of Metasystox.

*Counts of Field Bees*

Counts of field bees were made in the area of the crop which had not been eaten down and where growth of the plants was uniform and luxuriant. They were confined to a part of this area marked with poles and tape and measuring 100 × 177 yd. (Fig. 1).

The sweep method used successfully by Palmer-Jones *et al.*[6] for counting bees in fields of white-clover pasture could not be employed in the chou moellier crop as it varied in height from 5 to 7 feet, so a method of direct counting was used. Two operators walked slowly across the 100 yd. axis of the marked area counting all the bees in their forward range of vision. They then walked back and the number of bees counted by both in a total of 400 yd. was noted. Because in their passage through the crop the operators counted bees in a strip approximately one yard wide, the total bee count was really for 400 sq. yd. and if multiplied by 12.1 gave the number of bees per acre (Fig. 3). However, throughout this work bee densities per acre were obtained by multiplying total bee counts for 400 sq. yd. by 12. The use of this convenient round figure was considered warranted because bee counting is subject to many sources of error. Throughout the experiment counts were made by the same two operators who traversed different portions of the crop in each 100-yd. sweep.

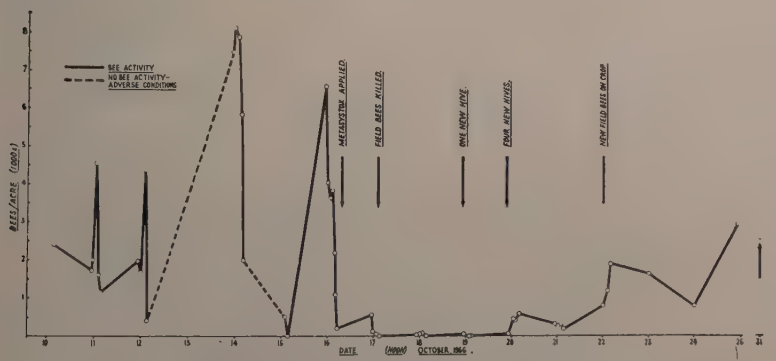


Fig. 3.—Bees per acre of crop (all counts).

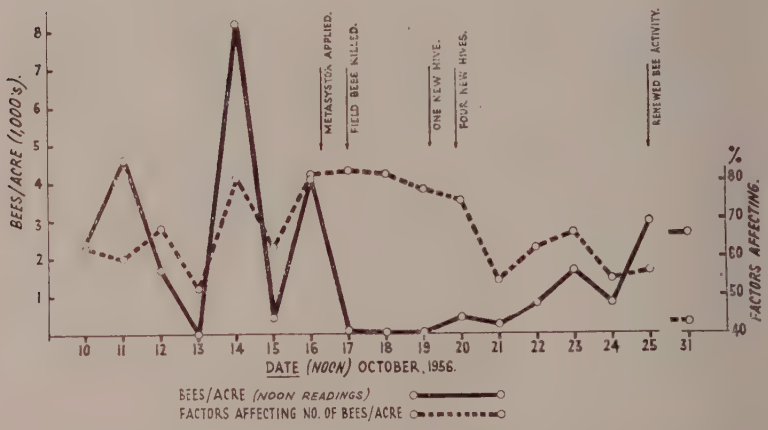


Fig. 4—Bees per acre of crop (noon counts) and factors affecting bee concentration.

There is a tendency for bees in a crop to move away from operators engaged in making sweeps or counting and some will always be overlooked, so the figures denoting bees per acre plotted in Figs. 3 and 4 are underestimates. But it is considered that they give a very accurate and consistent picture of bee activity.

## RESULTS

*Counts of Field Bees*

Bee counts commenced on 10 October and showed peaks of activity about noon on the 11th and 12th. There was no bee activity on the 13th and maximum activity all day on the 14th, when the density of bees per acre was estimated at over 8,000 (Table 1 and Fig. 3). On the 15th, bee activity was slight owing to adverse weather conditions. There was maximum activity on the 16th until 3 p.m. when it rapidly declined until no bees were flying by 5.30 p.m.; the greatest density of bees per acre was estimated at over 6,500. The crop was sprayed between 6 and 7 p.m.

Weather conditions were ideal throughout the 17th, and field bees would have commenced to visit the crop about 7 a.m., although the first bee count was not made until 10.30 a.m. This gave a density of only 550 bees per acre compared with over 6,500 at the same time on the previous day. Bee activity rapidly declined to zero during the day. In spite of fine weather on the 18th and 19th, the densitiy of bees per acre was negligible. On the 19th a greater quantity of nectar was observed in the flowers of the crop than hitherto.

Hive and other observations proved that the cessation of bee activity on the crop after the spray was applied on the 16th was due to the Metasystox having killed virtually all the field bees.

It was essential to replace the field bees on the crop so as to discover how long bee mortality would continue after the spraying. Accordingly, an additional hive (No. 19) was put on the site early on the morning of the 19th. Although this hive had a strong field force of bees these did not visit the crop, and counts remained at zero. On the 20th, four more strong hives (Nos. 20, 21, 22, 23) were brought to the experimental area and established on the side of the crop opposite the main apiary. Bees from hive No. 19 were still not on the crop to any extent. Although conditions were ideal for bee flight throughout the day, and the crop was bearing nectar heavily, the first counts were practically zero and binocular examination showed no bee activity over the crop. However, when bees were released from the four new hives at 10.45 a.m. they commenced almost immediately to visit the crop nearby and subsequent counts during the day were higher than at any time since the spraying.

Conditions did not favour bee activity on the 21st, and counts were lower than on the previous day. It was apparent that most bees on the crop came from hives numbers 20 to 23, particularly as highest counts were obtained in the corner adjacent to them.

Although weather conditions on the 22nd were not favourable, the highest counts since spraying were obtained. It was noticed that, apart from the five new hives, bees from the original hives also were commencing to visit the crop. These were young bees which were foraging for the first time.

Weather conditions were good on the 23rd, and a count gave much the same density of bees per acre as on the day before.

On the 24th, weather conditions were poor and the count was low. It was noted that all hives on the site were now working the crop.

On the 25th, weather conditions were ideal and, in spite of the crop having gone rapidly to seed, the highest count since spraying was obtained.

A final count made on the 31st, when weather conditions were good but the crop had mainly gone to seed, was nearly as high as on the 25th.

Counts were made on a crop of chou moellier at Methven. The flowers in this crop were of maximum attractiveness to bees and conditions favoured bee activity more than any experienced at the experimental area. Also the Methven area was very heavily stocked with bees, unlike the experimental area, which depended upon the one apiary. Combined bee counts (400 yd.) were 1,239 plus one bumble bee (*Bombus terrestris*). This equals 14,868 bees per acre compared with a maximum of 8,150 on the experimental crop.

*Bee Activity on Crop*

In Fig. 4 the number of bees per acre of crop is plotted against factors affecting bee density.

The graph showing bee density was based on the bee counts made closest to noon when bee activity was usually greatest.

Factors affecting bee density were plotted daily, with a maximum of 100 points, of which 50 represented the attractiveness of the chou

moellier flowers and 50 climatic influences—temperature, wind, and sun (Table 2). Sixteen points were allotted to temperature which was

TABLE 2. FACTORS AFFECTING DENSITY OF BEES ON CROP

| Oct. | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|
| Attractiveness of flowers in crop (Max. rating 50) | 40 | 42 | 44 | 46 | 48 | 50 | 50 | 50 | 47 |
| Climatic influences | | | | | | | | | |
| Temperature (16) | 6 | 6 | 6 | 2 | 10 | 2 | 7 | 9 | 9 |
| Wind (16) | 10 | 5 | 6 | 4 | 7 | 9 | 7 | 6 | 8 |
| Sun (18) | 7 | 7 | 12 | 0 | 16 | 2 | 18 | 18 | 18 |
| (Max. rating 50) | | | | | | | | | |
| Total | 63 | 60 | 68 | 52 | 81 | 63 | 82 | 83 | 82 |

| Oct. | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 31 |
|---|---|---|---|---|---|---|---|---|
| Attractiveness of flowers in crop (Max. rating 50) | 44 | 41 | 38 | 35 | 35 | 30 | 20 | 2.5 |
| Climatic influences | | | | | | | | |
| Temperature (16) | 14 | 9 | 7 | 6 | 9.5 | 11.5 | 10 | 12.5 |
| Wind (16) | 4 | 9 | 3 | 9.5 | 5 | –2 | 8.5 | 10 |
| Sun (18) | 16 | 16 | 6 | 12 | 16 | 15 | 18 | 18 |
| (Max. rating 50) | | | | | | | | |
| Total | 78 | 75 | 54 | 62.5 | 65.5 | 54.5 | 56.5 | 43.0 |

calculated over the range 50°–82°F., the figures in Table 2 being obtained by subtracting fifty from the maximum temperature reading on the thermohygrograph chart and multiplying the figure obtained by 0.5. Sixteen points were allotted to wind, the average daily wind velocity being subtracted from sixteen to give the figures in Table 2. Eighteen points were allotted for daily hours of sunshine.

It is realised that this method of assessing the factors affecting bee concentration is arbitrary, but as will be seen Fig. 4 does give a complete and realistic picture of events on the crop during the experiment. Fig. 4 shows that peaks of bee activity coincide with peaks in the graph of factors affecting bee concentration. For some days after Metasystox was applied, factors affecting bee concentration were most favourable, but bee counts remained negligible, until a slow recovery commenced as bees from the five new hives began to visit the crop. Finally, bee activity was renewed as fresh field bees from the original hives visited the crop. The graphs diverge rapidly at this point because, from the 20th onwards, the crop rapidly went to seed, depressing the lower graph, while increasing bee activity on the crop caused the top graph to rise.

*Behaviour of Bees on Crop*

It was noted on the day after the spray was applied that bees on the crop were not behaving normally, and many appeared reluctant to settle on the flowers.

Over 50% of bees observed on the 18th exhibited the same aversion for the flowers; they also seemed excited and angry, flying with quick, darting movements.

Bees were collecting nectar in a more normal fashion on the 22nd, and on the 25th were behaving as usual for the first time since the spray was applied.

*Poisoning of Bees by Metasystox*

At 9 a.m. on the day following the spray application, the apiary appeared normal except that in front of most hives a few bees were crawling on the ground and showing symptoms consistent with the effects of a nerve poison. (Before the experiment, one of us (T.P.-J.) had studied in the laboratory the effects of Metasystox on bees.) At 11 a.m. bees were observed clustering on the outside of most hives in distress; some were having convulsions and attempting to sting each other as in severe Metasystox poisoning; many dead bees had been brought out of the hives. Later the clustered bees re-entered the hives but it was noted that dead continued to be brought out. (Observations ceased at 5 p.m.).

The hive temperature of a colony examined at noon was noticeably above normal and the bees were distressed and noisy; all stages of brood appeared normal and brood care was being maintained.

The two colonies actually in the crop showed no obvious distress and few dead bees were brought out. This could have been due to the loss of field bees which occurred when these hives were moved from the main apiary, having left only a small field force to be affected by the Metasystox.

Most bees that could be closely observed in the crop were not behaving normally and many appeared reluctant to settle on the flowers. Bee counts soon declined almost to zero and the majority of bees seen on the crop were incapable of flight. Poisoned bees were observed in the line of flight between the hives and the crop. It was obvious that the field bees were being rapidly killed by the Metasystox (Figs. 3 and 4).

On the 18th, fewer dead bees were brought out of the hives than on the previous day. Brood rearing and hive activities were found to be proceeding as usual when four representative hives were examined, and queen bees were unaffected and laying normally. Examination of hives Nos. 17 and 18 in the crop showed that brood was normal and queens laying as usual. Before the spray application, hive No. 5 had been moved away from the apiary so as to leave its field bees behind. Consequently, this hive lost no field bees and when opened was found to be unaffected.

Bee mortality apparently ceased in the main experimental apiary on the 19th, as no dead bees were brought out of the hives from this date onwards, and no signs of poisoning were observed.

Because all the field bees from the original apiary had been killed, four new hives were brought to the crop to find how long it would remain toxic to bees. These hives were opened at 10.45 a.m. on the 20th and bees from them soon commenced to visit flowers in the crop. At 3.30 p.m. the bees in all four hives showed slight symptoms of Metasystox

poisoning, although apparently none died; they clustered round hive fronts and a few became excited. These symptoms subsided before long and were not shown again. The bees from the single hive brought to the crop on the 19th were not observed to visit the crop and were not affected.

All hives on the experimental site were examined on 14, 25, and 31 October. The two last examinations, made after the application of

TABLE 3. MORTALITY IN CAGED BEES COLLECTED FROM CROP BEFORE AND AFTER TREATMENT WITH METASYSTOX

| Date and Time of Collection | No. Bees Collected | Bees Dead After | | Remarks |
|---|---|---|---|---|
| | | 24 hr. | 48 hr. | |
| 10/10 | 25 | 0 | 0 | Control |
| 14/10 | | | | |
| 11 a.m. | 25 | 0 | 1 | Control |
| 1.30 p.m. | 25 | 0 | 0 | Control |
| 3.30 p.m | 25 | 0 | 2 | Control |
| 16/10 | | | | Control |
| 11 a.m. | 25 | 0 | 0 | Control |
| 2.30 p.m. | 25 | 0 | 1 | Metasystox applied 6.15–7 p.m. |
| 17/10 | | | | |
| 10.30 a.m. | 8 | All dead in 6 hours | | |
| Noon | 6 | | | |
| 2.30 p.m. | 4 | | | |
| 3.15 p.m. | 8 | | | |
| 1.30 p.m. | 8 | 2 | 2 | |
| 18/10 | | | | |
| 11.30 a.m. | 20 | 11 | 12 | |
| 1 p.m. | 5 | 4 | 5 | |
| 3 p.m. | 25 | 4 | 5 | These bees were collected from the experimental hives. |
| 19/10 | | | | |
| 12.15 p.m. | 40 | 1 | 3 | Controls collected from a nearby apiary |
| 12.30 p.m. | 40 | 3 | 3 | |
| 12.30 p.m. | 40 | 1 | 3 | |
| 20/10 | | | | |
| Noon | 21 | 4 | 6 | |
| 2.30 p.m. | 14 | 3 | 3 | |
| 4.0 p.m. | 16 | 1 | 2 | |
| 21/10 | | | | |
| 11 a.m. | 12 | 0 | 0 | |
| 2.45 p.m. | 6 | 2 | 2 | |
| 22/10 | | | | |
| 11.45 a.m. | 20 | 1 | 2 | |
| 3.0 p.m. | 25 | 0 | 1 | |
| 23/10 | | | | |
| 10.30 a.m. | 25 | 0 | 0 | |

the spray, showed normal hive activity and no signs of bee mortality. It is apparent that the Metasystox spray affected field bees only.

*Mortality in Field Bees*

The toxic action of the Metasystox was studied by the caging and observation of field bees. These were picked off chou moellier flowers and placed in cages kept in an incubator room at 80°F. The cages were supplied with feeders holding sugar syrup.

It will be seen from Table 3 that mortality in bees used as controls was negligible after 48 hours. On the 17th, the day after spraying, it was difficult to collect many field bees because so few were on the crop. Those collected all died within 6 hours, except for a final batch, caged at 4.30 p.m., of which only 25% died. By 4.30 p.m. bees were scarce, so all those caged were picked from flowers near the experimental hives where they were most numerous. It is possible that most bees collected had not been on the flowers a sufficient length of time to gather much nectar before they were caged. This factor could account for the low mortality. On the 18th, mortality in collected bees was high and remained so until the 21st. Bees collected on the 22nd and 23rd showed no undue mortality.

Metasystox is volatile and is also claimed to be readily and fully absorbed into plants, so it would not persist for long on the surface of the crop during the warm weather experienced after spraying. Mortality in collected bees must, therefore, have been caused by metabolites of Metasystox having reached the nectar.

*Effect on Bees of Extracts from Flowers*

Young chou moellier flowers were picked from the crop on 19 October and ground in a mortar; the extract was filtered through gauze, mixed with sugar syrup, and fed at 12.30 p.m. to 25 caged bees. The bees came from hive No. 5 from which a cage of 25 bees was taken at the same time as a control. Within 24 hours the bees fed the extract were all dead but the controls were unaffected. Unsprayed chou moellier flowers were treated similarly as a further control. Twenty-five caged bees were unaffected by the extract from these after 48 hours.

Young chou moellier flowers taken from the crop on the 21st were treated as above. Only one bee in 24 died 48 hr. after feeding on the extract.

It will be recalled that bees picked off flowers in the crop and caged showed the effects of metabolites of Metasystox in the nectar until the 21st.

*Effect on Pollen Collection*

On 10 October, pollen traps were placed on two hives. One trap was removed on the 22nd and the other left in position until the 31st.

Pollen analysis of pellets removed from a pollen trap on 16 October, just before Metasystox was applied, gave: chou moellier 94% of pellets, gorse 4%, storksbill 2%. Pellets removed on the 18th were 30% chou moellier, 67% gorse, and 2% storksbill; on the 22nd, they were less than 1% chou moellier, 99% gorse, and less than 1% storksbill; on the

25th they were 2% chou moellier, 92% gorse, 5% storksbill and 1% Compositae; finally, on 31 October the figures were 15% chou moellier, 80% gorse, 4% storksbill, and the rest from other sources.

Before the application of Metasystox, it had been observed that most of the pollen collected by the bees came from the chou moellier as confirmed by the pollen analysis. Although 30% of the pellets collected between the 16th and 18th were from chou moellier, the actual quantity of pollen brought in over this period was negligible. Pollen collection increased from the 18th onwards as fresh field bees replaced those killed by the spray, but only 1% of pellets removed on the 22nd, and 2% on the 25th, came from chou moellier. Even on October 31st only 15% of pellets came from the chou moellier.

Pollen was abundant on the crop during the period following spraying. But it had apparently suffered a physical change which prevented bees collecting it in appreciable amounts until after 25 October.

No adverse effect on seed set was observed in the crop through the lack of attractiveness of the pollen for this short period.

*Identification of Bees in Crop*

The direction of flight lanes showed that the chou moellier crop was being worked by bees from the experimental apiary, and no commercial apiaries were within ordinary bee range. However, to establish what proportion of bees on the crop came from experimental hives, bee markers were used to mark the bees with aluminium paint powder as they left the hives. These bee markers, developed by Nairn[7] had been used successfully before in the field by Palmer-Jones *et al.*[6]

Bee markers were put on the eighteen hives at 11.15 a.m. and removed at 4 p.m. on 12 October. Within an hour, approximately 90% of the bees sighted during counts were marked. Later in the day, 100% of bees on the crop were marked, showing that all bees on the crop came from the experimental apiary.

*Sugar Content of Nectar*

The sugar content of chou moellier nectar was determined by removing the honey sacs of field bees and placing the contents on the prism of a pocket refractometer graduated to give sucrose as a percentage (Table 4). This method has been found by other workers to give satisfactory results in the field[8].

It is of interest to note that it was only when the crop was commencing to go rapidly to seed that the sugar content exceeded 50%.

*Chemical Analyses*

Samples of chou-moellier flower heads and leaves were collected at intervals before and after spraying. Several pounds of poisoned bees, and pollen trapped during the experiment, were also available. Honey was not gathered from the crop by the main apiary after spraying because all the field bees were killed. However, a sample of chou-moellier honey brought in after spraying was taken from hives Nos. 20–23 on 25 October. The results of chemical work will be reported in a later paper.

TABLE 4. REFRACTOMETER READINGS

| Date and Time of Readings | Number of Readings | % Sucrose (Average of Readings) | Date and Time of Readings | Number of Readings | % Sucrose (Average of Readings) |
|---|---|---|---|---|---|
| 10/10 | | | 17/10 | | |
| 4 p.m. | 2 | 28 | 1.30 p.m. | 3 | 33* |
| 11/10 | | | | | |
| 10.45 a.m. | 6 | 27 | 20/10 | | |
| 12.45 p.m. | 3 | 38 | 11.30 a.m. | 6 | 0† |
| 2 p.m. | 6 | 34 | 2 p.m. | 3 | 39 |
| 12/10 | | | | | |
| 10 a.m. | 6 | 24 | 22/10 | | |
| 1.15 p.m. | 6 | 29 | 11 a.m. | 4 | 17.5 |
| 3 p.m. | 3 | 27 | 3.15 p.m. | 6 | 34.33 |
| 14/10 | | | | | |
| 10.30 a.m. | 6 | 41 | 23/10 | | |
| 1 p.m. | 6 | 43 | 11 a.m. | 6 | 43 |
| 3.15 p.m. | 6 | 32 | | | |
| 15/10 | | | 24/10 | | |
| 2 p.m. | 6 | 23 | 12.15 p.m. | 6 | 54 |
| 16/10 | | | | | |
| 10.30 a.m. | 6 | 27 | 25/10 | | |
| 12 45 p.m. | 6 | 32 | 10.45 a.m. | 6 | 54 |
| 3 p.m. | 6 | 30 | | | |

* at hives † at hives = water

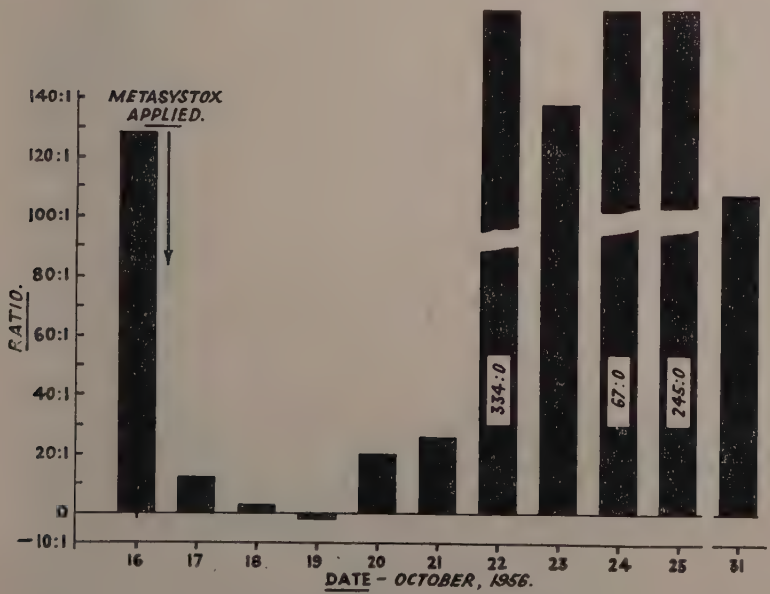


Fig. 5.—Ratio of honey bees to bumble bees (total daily counts).

*Action of Metasystox on Bumble Bees*

Fig. 5, based on total daily counts, shows the ratio of honey bees to bumble bees. It is seen that after spraying they first increase in numbers relative to hive bees and then there is a sharp decline to zero. All bumble bees observed were *Bombus terrestris* except during a final count on the 31st when 217 hive bees and two bumble bees, one *Bombus ruderatus*, were sighted. Apparently, fresh bumble bees were commencing to visit the crop. The graph shows that bumble bees are more resistant than hive bees to Metasystox but eventually succumb. The bumble bees observed were queens which would be building up their nests at this time of the year.

Two of the four bumble bees observed during counts on the 17th were showing typical symptoms of Metasystox poisoning and appeared unlikely to survive. On the 18th one of three bumble bees observed showed symptoms of poisoning.

*Protection of Observers Against Metasystox*

After the Metasystox was applied, overalls, rubber gloves, approved respirator, and eye shield were always worn in the crop. It was thought that the need to wear respirators had passed by the 20th, but when these were left off in the morning one operator experienced slight nausea and salivation. Respirators were dispensed with from the 22nd onwards without ill effects.

## DISCUSSION

Metasystox was applied at the maximum rate recommended in Britain. There were no bees on the crop when spraying ceased at 7 p.m. on the 16th, and approximately twelve hours elapsed before they commenced to visit it the next morning. Signs of "Metasystox" poisoning were first observed in the apiary at 9 a.m. on the day after spraying; mortality reached a peak at 11 a.m. and continued throughout the day. On the 18th, fewer dead bees were brought out of the hives, and after this date no signs of poisoning were observed in the apiary.

The greatest bee count obtained indicated that over 80,000 field bees at a time would be on the flowers of the crop when conditions favoured maximum activity. Assuming that an equal number of field bees were in the hives as in flight, they would total 160,000. Only 16,400 dead bees were found in front of the hives and observations proved that the majority of the field bees had been killed by the Metasystox. Therefore, most of the field bees died in the crop.

Hive examinations showed that Metasystox did not affect young bees or brood; brood maintenance and hive activities were unaffected. Mortality was confined to field bees. In the case of lindane poisoning at Darfield[1], a large number of young bees as well as field bees were killed, and brood was severely affected up to four days after the dusting, through lindane being carried into the hives. Although all the field bees were killed by the Metasystox it was considered that by the summer the hives would have built up a sufficiently strong field force to collect a honey crop. However, if Metasystox were applied to crops that flower later in the season, and a similar mortality occurred, there would be no time for the bees to build up a strong enough field force to bring in a honey crop. Lindane was applied as a dust, while the volatile

Metasystox was sprayed and would soon be absorbed into the plants or evaporate. It appears likely that the field bees were killed so quickly by the Metasystox that relatively few were able to bring it back to the hives and so cause secondary mortality by passing it on to young bees and brood.

Laboratory tests were carried out by one of us (TPJ) to obtain fuller information on the way in which Metasystox caused bee mortality. Bees were run back and forth from one cage to another through a wire gauze tube 8 in. long (1 in. diameter) moistened with a spray of 1% W/V Metasystox. After being in contact with the spray for 3 minutes the bees were caged and kept under observation. Mortality was 100% within 1 hour. Bees exposed in cages for 1½ hours to the vapour of 1% W/V Metasystox all died within 5 hours of removal from its influence.

The night following spraying had been cold with a high humidity and it was noticed, even at 10 a.m. the next morning, that the crop was damp and smelled of Metasystox.

It is thus apparent that some bee mortality must have occurred early on the morning of 17 October through bees contacting the spray itself and being also affected by its vapour. However, Metasystox is volatile and readily absorbed by plants and so would not have persisted long on the surface of the crop.

The toxicity to bees of dry films of Metasystox was studied by the method described by Glynne Jones and Connell[9]. Metasystox was sprayed over 600 sq. cm. of grease paper, which was used, when the spray had dried, to line completely the inside of a cage. Fifty bees were placed inside the cage for one hour and were then removed and kept under observation in another cage supplied with sugar syrup. Mortality after 48 hours was noted. Bees exposed to 0.0108 g. per 600 sq. cm. for one hour were unaffected, and it required a concentration of 0.0512 g. per 600 sq. cm. to cause 28% mortality. If Metasystox in the strength used in this experiment was sprayed over a flat area and allowed to dry it would be present in a concentration of 0.0038 g. per 600 sq. cm. So it is concluded that when dry the Metasystox spray would be no hazard to bees.

Individual bees were dosed Metasystox with a micrometer syringe using the method developed by Glynne Jones and Connell[9]. The LD 50% of Metasystox as a stomach poison for bees was found to be 0.5 $\mu$g. When sprayed on plants Metasystox reaches the nectar in the form of metabolites. The toxicity of these to bees could not be estimated as they were not available.

Nectar gatherers picked off the flowers early on the morning after spraying died rapidly, and probably most mortality was caused by metabolites of Metasystox in the nectar, which was found to be poisonous to bees for five days after spraying. Extracts of chou-moellier flowers were highly toxic to bees on the 19th but not the 21st October.

The Metasystox used in these experiments was the same as that supplied by Leverkusen Bayer for application to the chou moellier.

The four new hives whose bees first visited the site on the 20th showed only slight symptoms of poisoning and no dead bees were brought

out. However, as shown by Table 3, mortality in nectar gatherers was still occurring on the 20th and 21st, so although these hives did not suffer any obvious depletion in field strength some loss must have occurred.

The crop appeared to exert some degree of repellency to bees after spraying and they did not collect nectar in a normal fashion until the 25th October, but they continued to visit it throughout the period when it was toxic.

A noticeable feature of bee activity after the application of Metasystox was that field bees ceased to collect chou-moellier pollen and turned their attention to competing sources (storksbill, gorse). Even when bees were at last collecting nectar normally again from the crop only a few would bring in chou-moellier pollen. It appeared that they were unable to pack the pollen into their pollen baskets through its physical nature having changed in some way. It is possible that the emulsifying agent in the Metasystox was the cause, as the pollen appeared dry and lacked normal adhesive qualities.

All the bumble bees visiting the crop were killed by the spray. Because these were queens that had commenced to build up nests, their deaths would result in the loss of an equivalent number of colonies.

## CONCLUSIONS

This experiment shows that Metasystox should on no account be applied to flowering crops attractive to bees. Although mortality of nectar gatherers ceased five days after spraying, the danger period may vary with different plants and be affected by climatic and other factors. In the case of chou moellier, the bees could not collect pollen after spraying, but, with different spray formulations or crops, contaminated pollen might be brought into hives. Until further experiments can be carried out it is advisable for these reasons not to spray crops with Metasystox for at least a fortnight before flowering can be expected.

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# FUSED PHOSPHATE FERTILIZERS

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## Summary

Several fused-phosphate fertilizers and basic slag were compared with superphosphate for pasture topdressing on Ohaupo silt loam on the basis of equivalent applications per acre of total $P_2O_5$.

The phosphate treatments gave significant overall yield increases of the order of 25% above the control (no manure).

The comparisons of total yield data for the 4½-year period have shown only small differences between types of fertilizers. Calcium magnesium phosphate gave the highest total yield, 2.7% higher than superphosphate, but this difference was not statistically significant.

Super, being quick acting, gave superior pasture production in the autumn, when applied sufficiently early.

Basic slag and the fused-phosphate fertilizers showed to advantage in summer production.

All fertilizers yielded slightly better in combination with carbonate of lime.

The effect of the various fused fertilizers, basic slag, and superphosphate on the soil test for phosphorus was very much the same.

Superphosphate caused a slight but statistically significant decrease in soil pH, whereas basic slag and four of the fused fertilizers significantly increased it.


## INTRODUCTION

The world shortage of sulphur and its reduced allocation to New Zealand from the United States seriously threatened the manufacture of superphosphate at the beginning of this decade. Since then the position has improved considerably, owing to the discovery of new sulphur domes in U.S.A., and supplies of sulphur are at present adequate for New Zealand industry.

Sulphur consumption, however, continues to expand rapidly, and it cannot be foreseen for how long adequate and comparatively cheap sulphur supplies will be available.

The insecure position in 1950–51 and the demand for more-concentrated phosphatic fertilizers tended to focus attention on products that do not require the use of sulphur in their manufacture. In order to compare some of these materials with superphosphate, an experiment was established at Rukuhia Soil Research Station, in which several United States and Japanese products, as well as basic slag, were tested.

The manufacture of fused fertilizers used in this trial is as follows:

*Thermophos: Calcium Magnesium Phosphate: Fused Magnesium Phosphate*

These are similar materials prepared from mixtures of phosphate rock and magnesium-bearing minerals (approximately in the proportion of 2:1) fused in an electric furnace. The molten product is quenched in a stream of water, dried without further curing, and pulverized. They are all basic phosphates and could probably be used successfully,

especially where basic slag and North African phosphate have proved suitable.

*Metaphos (calcium metaphosphate)*

Elemental phosphorus produced by the electric-furnace method is burnt. The resulting $P_2O_5$ reacts with phosphate rock at high temperatures. This is the most concentrated of the fertilizers tested.

*Fused Tricalcium Phosphate*

This is produced by the fusion of phosphate rock and silica in a shaft furnace fired with either oil or gas. The molten product is tapped from the furnace into a stream of water to quench and granulate, and is then dried and ground for distribution[1]. All these fertilizers contain phosphate that is insoluble in water yet available to plants.

## EXPERIMENTAL

The trial from which the data for this investigation were obtained was established on Ohaupo silt loam containing some wash from Hamilton clay loam. It was laid down on 3 August 1951. Ohaupo silt loam is an immature yellow-brown loam derived from andesitic ash of the Macroa shower[2]. Hamilton clay loam is a semi-mature brown granular clay loam derived from volcanic ash, which is thought to be of andesitic composition[3].

The area upon which the trial was established was in permanent pasture from 1946 onwards. The manurial history for the years 1947–50 was: 1947–49, 3 cwt. super annually; 1950, 3 cwt. super and 100 lb. ammonium nitrate.

The initial soil test for phosphorus was low, 2 units, and the pH was 5.5. (The phosphorus index is based on determinations by the Truog method and indicates parts P per 50 million of the soil extract.) A split-plot layout was used, in which each of the three main blocks contained one limed and one unlimed sub-block. Carbonate of lime was applied at the rate of 5 cwt. per acre annually.

TABLE 1. FERTILIZERS USED AND THEIR $P_2O_5$ CONTENTS

| Fertilizer | Total $P_2O_5$ | Citric Sol. $P_2O_5$ | Water Sol. $P_2O_5$ |
|---|---|---|---|
| Superphosphate | 22.4 | | 18.9 |
| Basic slag | 17.2 | 16.3 | |
| Fine thermophos | 20.3 | 19.1 | |
| Granulated thermophos | 20.1 | 15.9 | |
| Metaphos | 63.2 | 5.8 | 1.4 |
| Fused tricalcium phosphate | 27.1 | 18.0 | 0.13 |
| Calcium magnesium phosphate | 23.3 | 22.8 | |
| Fused magnesium phosphate | 20.4 | 20.0 | |

The above fertilizers were applied at rates giving the same amount of total $P_2O_5$ per acre as 3 cwt. superhposphate. The dates of topdressing were 3 August 1951, 14 May 1952, 14 April 1953, 23 March 1954, and 5 April 1955.

The trial was carried out under "mowing and clippings returned" technique[4]. The production was measured by 64 cuts.

*Soil Analyses.* The soil samples were analysed three times—in 1951 before the first treatment, in 1953 before the third treatment, and in 1955 before the fifth treatment.

*Botanical Analyses.* Herbage samples for botanical analyses by dissection of mown herbage were collected 18 times during the course of the trial.

## RESULTS

Fig. 1 indicates the differences in dry-matter production of herbage of various treatments from superphosphate assessed at 100.

The significance of the differences is shown in Table 2:

TABLE 2. SIGNIFICANCE OF DIFFERENCES FROM SUPERPHOSPHATE IN DRY-MATTER PRODUCTION

| Season | Less than Super | | More than Super | |
|---|---|---|---|---|
| | At 5% level | At 1% level | At 5% level | At 1% level |
| Spring 51 | — | — | — | — |
| Summer 51–52 | Control | — | — | — |
| Autumn 52 | — | Control | — | — |
| Winter 52 | — | Control | — | — |
| Spring 52 | Control | — | — | — |
| Summer 52–53 | — | Control | Trs. 5, 6, 8 | Tr. 3 |
| Autumn 53 | Tr. 3, 9 | Control<br>Tr. 7 | — | — |
| Winter 53 | — | Control | Tr. 5 | — |
| Spring 53 | — | — | — | — |
| Summer 53–54 | Control | — | Trs. 3, 5, 8 | — |
| Autumn 54 | Trs. 4, 6, 8 | Control<br>Trs. 5, 7, 9 | — | — |
| Winter 54 | — | Control | — | — |
| Spring 54 | Control | — | Trs. 5, 6 | — |
| Summer 54–55 | — | Control | — | — |
| Autumn 55 | Trs. 3, 5, 6, 9 | Control<br>Tr. 7 | — | — |
| Winter 55 | — | Control | — | — |
| Spring 55 | — | Control | — | — |
| Summer 55–56 | — | Control | — | — |

For Treatments see Fig. 1.

Table 3 summarizes the seasonal yields of the various treatments relative to superphosphate 100:

TABLE 3. SEASONAL DRY-MATTER PRODUCTION RELATIVE TO SUPERPHOSPHATE (100)

| Treatments | Autumn | Winter | Spring | Summer | 4½-yr. Totals | |
|---|---|---|---|---|---|---|
| | | | | | Yields lb./ac. | Relatives |
| 1. Control | 63 | 71 | 93 | 79 | 26,810 | 81 |
| 2. Superphosphate | 100 | 100 | 100 | 100 | 33,200 | 100 |
| 3. Basic slag | 95 | 106 | 101 | 107 | 33,960 | 102 |
| 4. Fine thermophos | 95 | 101 | 99 | 103 | 33,120 | 100 |
| 5. Granul. thermophos | 93 | 102 | 99 | 104 | 33,110 | 100 |
| 6. Metaphos | 94 | 100 | 102 | 103 | 33,470 | 101 |
| 7. Fused tricalc. phosph. | 87 | 97 | 102 | 102 | 32,740 | 99 |
| 8. Calc. mag. phosph. | 95 | 107 | 102 | 107 | 34,080 | 103 |
| 9. Fused mag. phosph. | 92 | 98 | 102 | 104 | 33,210 | 100 |

Table 4 shows analyses of soil samples from 0 to 3 inches.

TABLE 4. pH AND PHOSPHORUS VALUES FOR 0–3 IN. SOIL SAMPLES

| Treatments (mean of no lime and lime) | 10.5.51 | | 18.3.53 | | 21.3.55 | |
|---|---|---|---|---|---|---|
| | pH | Truog *P Units | pH | Truog P | pH | Truog P |
| 1. Control | 5.57 | 2.0 | 5.67 | 2.2 | 5.77 | 3.0 |
| 2. Superphosphate | 5.57 | 2.3 | 5.62 | 2.8 | 5.65 | 4.8 |
| 3. Basic slag | 5.52 | 2.3 | 5.72 | 2.8 | 5.93 | 4.5 |
| 4. Fine thermophos | 5.52 | 1.9 | 5.73 | 2.7 | 5.87 | 4.7 |
| 5. Granulated thermophos | 5.55 | 2.1 | 5.72 | 3.3 | 6.03 | 5.2 |
| 6. Metaphos | 5.50 | 2.1 | 5.62 | 2.6 | 5.72 | 4.5 |
| 7. Fused tricalcium phos. | 5.50 | 2.0 | 5.67 | 2.4 | 5.77 | 4.5 |
| 8. Calcium mag. phosphate | 5.48 | 2.1 | 5.70 | 2.7 | 5.92 | 4.3 |
| 9. Fused mag. phosphate | 5.60 | 2.3 | 5.77 | 2.6 | 6.00 | 5.0 |
| Sig diff, 5% | — | — | — | 0.45 | 0.09 | 0.8 |
| 1% | — | — | — | 0.61 | 0.12 | 1.0 |
| No Lime Mean all | 5.60 | 2.2 | 5.59 | 2.6 | 5.66 | 4.3 |
| Lime treatments | 5.47 | 2.0 | 5.78 | 2.7 | 6.04 | 4.7 |
| Significance of Lime effect | NS | NS | 5% | NS | 1% | NS |

*Parts P per 50,000,000 of Soil Extract.

Table 5 shows the effect of various treatments on botanical composition of the pasture:

TABLE 5. EFFECT OF SUPERPHOSPHATE, SUPERPHOSPHATE + LIME, AND FINE THERMOPHOS ON BOTANICAL COMPOSITION OF PASTURE

| Treatment | Mean Percentage of Species (1951–55) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Lolium perenne* | *Dactylis glomerata* | *Anthoxanthum odoratum* | *Holcus lanatus* | Other grasses | *Trifolium pratense* | *Trifolium repens* | Other clovers | Weeds | All grasses | All clovers |
| Control | 44 | 10 | 5 | 1 | 9 | Tr. | 24 | Tr. | 7 | 69 | 24 |
| Super | 48 | 5 | 1 | 1 | 14 | Tr. | 26 | Tr. | 6 | 68 | 26 |
| Super + Lime | 46 | 4 | 2 | 1 | 15 | Tr. | 26 | Tr. | 6 | 68 | 26 |
| Fine Thermophos | 44 | 5 | 2 | 1 | 15 | Tr. | 26 | 1 | 6 | 67 | 27 |

Tr. = Trace.

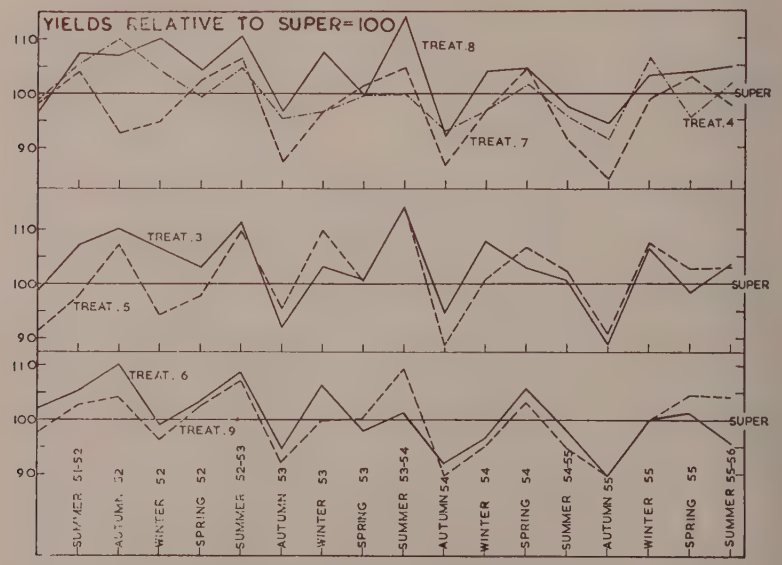


Fig 1.—Dry-matter yields relative to superphosphate 100. *1.* Control. *2.* Super. *3.* Basic slag. *4.* Fine thermophos. *5.* Granulated thermophos. *6.* Metaphos. *7.* Fused tricalcium phosphate. *8.* Calcium magnesium phosphate. *9.* Fused magnesium phosphate.

## DISCUSSION

### *Phosphate Effect*

The yield differences between types of phosphate fertilizer were small, but the following significant effects were found:

(a) Superphosphate gave significantly higher yields than basic slag and some of the fused phosphates in the autumns of 1953, 54, and 55, when the applications were made sufficiently early.

(b) In the summers of 1952–3 and 1953–4, basic slag, granulated thermophos, and calcium magnesium phosphate gave significantly higher yields than superphosphate; and metaphos was also significantly better in the summer 1952–3.

(c) Granulated thermophos gave significantly higher yields in the winter of 1953 and in the spring of 1954, while metaphos gave significantly better results in spring 1954.

*Seasonal Production*

The highest relative responses from all fertilizers were obtained in autumn. Superphosphate showed itself to be quicker acting than the rest of the fertilizers. Its superiority was visible shortly after top-dressing (providing a sufficient amount of rain fell after the application) and lasted for approximately two months. It is interesting to note that by winter the yields from all fertilizers were very close to that of superphosphate. In summer, fused fertilizers and basic slag usually yielded more than superphosphate.

*Total Production*

Calcium magnesium phosphate gave the highest overall yield, but was only 2.7% better than superphosphate. On the basis of annual production it was not significantly better than superphosphate.

The lowest yielding—1.4% below super—was fused tricalcium phosphate. It yielded significantly less than superphosphate in 1953–54.

All other fertilizers gave almost identical total yields with superphosphate.

*Effect of Lime*

Lime slightly increased the production of all fertilizers in all seasons. The average increase from all treatments over $4\frac{1}{2}$ years was 6%.

The highest lime responses were usually obtained in summer and autumn, and the lowest in spring. Lime effect was significant only in summer 1952–53 and spring 1955.

*Analyses of Soil Samples*

After four annual applications of the treatments, i.e. 12 cwt. superphosphate, or its equivalent in the above fertilizers, the soil test for phosphorus rose only slightly. Soils treated by the various fertilizers did not differ significantly from superphosphate-treated soils. Granulated thermophos, however, raised the soil test for phosphorus significantly higher (at 5% level) than calcium magnesium phosphate.

Four annual 5 cwt./acre applications of carbonate of lime (i.e. 1 ton) raised the pH from 5.6 (1951) to 6.04 (1955). By 1955 superphosphate had significantly decreased pH from a mean value of 5.77 in the control to 5.65. On the other hand, pH was raised significantly by granulated thermophos, fused magnesium phosphate, basic slag, and calcium magnesium phosphate (at 1% level) and by fine thermophos

(at 5% level). The latter fertilizers yielded best in summer and also in autumn before the application of fertilizers. The summer and early autumn responses of these fertilizers may be attributed partly to their lime components.

*Analyses of Herbage Samples*

Herbage dissection analyses were based on dry weight of mown samples. In Table 5, the means of all analyses are given for control, superphosphate, superphosphate + lime, and fine thermophos. The effects of the above treatments on botanical composition of the pasture was very small, control plots showing slightly more *Dactylis glomerata, Anthoxanthum odoratum* and weeds, with slightly less other grasses (mainly *Poa annua* and *Poa trivialis*) and clovers than the treated plots.

The individual analyses taken at intervals throughout the experiment, not given in this paper, showed that during the course of the trial the amount of *D. glomerata, A. odoratum,* and *P. annua* increased at the expense of *Lolium perenne.* Furthermore, there were the usual seasonal changes in the sward composition, i.e., grasses dominant in winter and spring, and clovers dominant in summer and early autumn.

## Conclusions

Basic slag and fused phosphatic fertilizers on Ohaupo silt loam yielded very similarly to superphosphate when applied at the equivalent rates per acre of total $P_2O_5$.

All phosphate fertilizers gave significant increases in production, approximately 25% above the control.

Calcium magnesium phosphate gave the highest yield, 2.7% above superphosphate (not statistically significant).

Superphosphate showed itself to be quicker acting after early autumn topdressing than any of the other fertilizers used.

All fertilizers yielded slightly better in combination with carbonate of lime, but the lime effect was significant only in summer 1952–53 and spring 1955.

The soil test for phosphorus was raised by the fused fertilizers approximately to the same extent as by superphosphate.

Basic slag and four of the fused fertilizers significantly increased the pH. Superphosphate, however, caused a slight but statistically significant decrease in pH.

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# THIRD SUPPLEMENT TO "A REVISED LIST OF PLANT DISEASES RECORDED IN NEW ZEALAND", 1955-1957

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## Introduction

In this supplement are listed 77 diseases on 97 host plants. It includes diseases and host plants recorded in publications since the preparation of the "Second Supplement (Brien and Dingley 1955), new records, and additional host records.

*Corticium salmonicolor* is recorded for the first time, while *Sphaceloma* sp. on *Feijoa sellowiana* has been relisted as *S. psidii* and *Phytophthora cactorum* on *Humulus lupulus* as *P. cactorum* var. *applanata*.

**Acacia baileyana** F. v. Muell.
*Uromycladium notabile* (Ludw.) McAlp. — Baker 1956
**Allium ascalonicum** L.
*Puccinia porri* (Sow.) Wint. — Baker 1956
**Allium cepa** L.
*Puccinia porri* (Sow.) Wint. — Baker 1956
**Allium fistulosum** L.
*Puccinia porri* (Sow.) Wint. — Dingley 1957
**Allium sativum** L.
*Sclerotium cepivorum* Berk. — Additional host record
**Allium schoenoprasum** L.
*Puccinia porri* (Sow.) Wint. — Dingley 1957
**Anthoxanthum odoratum** L.
*Puccinia graminis* Pers. — Baker 1956
**Aristotelia fruticosa** Hook. f.
*Erysiphe polygoni* DC. — Dingley and Brien 1956
**Aristotelia serrata** (Forst.) Oliver
*Cercospora aristoteliae* Cke. — Cooke 1890
**Armeria maritima** Willd.
*Uromyces armeriae* (Schlecht.) Lev. ex Kickx. — Additional host record
**Armeria plantaginea** Willd.
*Uromyces armeriae* (Schlecht.) Lev. ex Kickx. — Baker 1956
**Avena sativa** L.
*Ascochyta avenae* (Petrak) Sprague & A. G. Johnson — Wratt 1956
*Fusarium avenaceum* (Fr.) Sacc. — Wratt 1956
*Pellicularia filamentosa* (Pat.) Rogers — Wratt 1956

**Bidens pilosa** L.
*Uromyces bidentis* Lagerh. — Baker 1956
**Brachycome sinclairii** Hook. f.
*Albugo tragopogi* S. F. Gray (syn. *Cystopus cubicus* de Bary) — Baker 1955
**Brassica campestris** L.
*Albugo cruciferarum* S. F. Gray (syn. *Cystopus candidus* Lev.) — Baker 1955
**Brassica oleracea** L. var. **ramosa** Alef.
*Alternaria brassicicola* (Schw.) Wilt. — Additional host record
**Bromus gussonii** Parl.
*Puccinia elymi* Westend. — Baker 1956

| | |
|---|---|
| **Ceanothus** sp. | |
| *Cercospora ceanothi* Killerman & Swingle | New record |
| **Cardamine heterophylla** (Forst. f.) O. E. Schulz. | |
| *Peronospora parasitica* (Pers.) Tul. | Additional host record |
| **Carex gaudichaudiana** (Boott) Kunth. | |
| *Puccinia caricina* DC. ex Jorstad | Baker 1956 |
| **Citrus sinensis** Osb. | |
| Psorosis | Anon. 1956 |
| **Coriaria angustissima** Hook. f. | |
| *Sphaerotheca humuli* var. *fuliginea* (Schlecht.) Salmon | Dingley and Brien 1956 |
| **Cotoneaster** sp. | |
| *Stereum purpureum* Pers. | Cunningham 1957 |
| **Cotula australis** (Less.) Hook. f. | |
| *Albugo tragopogi* S. F. Gray (syn. *Cystopus cubicus* de Bary) | Baker 1955 |
| **Craspedia uniflora** Forst. | |
| *Albugo tragopogi* S. F. Gray (syn. *Cystopus cubicus* de Bary) | Baker 1955 |
| **Crataegus oxyacantha** L. | |
| *Stereum purpureum* Pers. | Cunningham 1957 |
| **Cupressus macrocarpa** Hartw. | |
| *Stereum purpureum* Pers. | Cunningham 1957 |
| **Cynodon dactylon** (L.) Pers. | |
| *Puccinia cynodontis* Lacr. in Desm. | Baker 1956 |
| **Dahlia** sp. cult. | |
| *Oidium* sp. | Dingley and Brien 1956 |
| **Deschampsia caespitosa** (L.) Beauv. | |
| *Puccinia graminis* Pers. | Baker 1956 |
| **Dianthus caryophyllus** L. | |
| *Pellicularia filamentosa* (Pat.) Rogers | Additional Host Record |
| **Edwardsia prostrata** Buch. | |
| *Uromyces edwardsiae* G. H. Cunn. | Baker 1956 |
| **Euphorbia peplus** L. | |
| *Melampsora euphorbiae* (Schub.) Cast. | Baker 1956 |
| **Euphorbia pulcherrima** Willd. | |
| *Corynebacterium poinsettiae* Starr. & Pirone | Cunningham 1956 |
| **Feijoa sellowiana** Berg. | |
| *Sphaceloma psidii* Bitanc. & Jenkins (previously recorded as *Sphaceloma* sp.) | Jenkins and Bitancourt 1955 |
| **Gentiana antarctica** T. Kirk | |
| *Puccinia tararua* G. H. Cunn. | Baker 1956 |
| **Gypsophila paniculata** L. | |
| *Sclerotinia sclerotiorum* (Lib.) de Bary | Additional Host Record |
| **Hebe hulkeana** (F. Mueller ex Hook.) Ckn. & Allan | |
| *Peronospora grisea* Unger | Dingley and Brien 1956 |
| **Hippeastrum** sp. | |
| *Stagonospora curtisii* (Berk.) Sacc. | Dingley and Brien 1956 |
| **Hoheria sexstylosa** Col. | |
| *Irenopsis hoheriae* Hansford | Hansford 1955 |
| **Hordeum murinum** L. | |
| *Puccinia anomala* Rostrup | Baker 1956 |
| **Humulus lupulus** L. | |
| *Phytophthora cactorum* (Lib. & Cohn) Schroet. var. *applanata* K. P. Chesters (previously recorded as *P. cactorum*) | Cunningham 1956 |
| Molybdenum deficiency | Askew and Watson 1956 |
| **Hydrocotyle elongata** A. Cunn. | |
| *Puccinia hydrocotyles* (Link) Cke | Baker 1956 |

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|---|---|
| **Iris xiphium** L. | |
| *Puccinia iridis* (DC.) Wallr. | Dingley and Brien 1956 |
| **Ixia** sp. | |
| *Botrytis cinerea* Pers. | Additional Host Record |
| **Juncus effusus** L. | |
| *Puccinia juncophila* Cke. & Mass. | Baker 1956 |
| **Juncus pusillus** Buchen. | |
| *Puccinia juncophila* Cke. & Mass. | Baker 1956 |
| **Knightia excelsa** R. Br. | |
| *Microthyriella phaeospora* Hansford | Hansford 1954 |
| **Lactuca sativa** L. | |
| *Septoria lactucae* Pers. | Dingley 1957 |
| *Erwinia carotovora* (Jones) Holland | Brien *et al.* in press |
| *Pseudomonas marginalis* (Brown) Stapp | Brien *et al.* in press |
| Cucumber-mosaic virus | Brien *et al.* in press |
| **Lagenophora petiolata** Hook. f. | |
| *Albugo tragopogi* S. F. Gray (syn. *Cystopus cubicus* de Bary) | Baker 1955 |
| **Lavatera cretica** L. | |
| *Puccinia malvacearum* Bert. | Baker 1956 |
| **Lepidium oleraceum** Forst. | |
| *Albugo cruciferarum* S. F. Gray (syn. *Cystopus candidus* (Pers. ex Chev.) Lev.) | Baker 1955 |
| **Lindsaya cuneata** C. Christen. | |
| *Milesia lindsayae* S. D. Baker | Baker 1956 |
| **Lolium perenne** L. | |
| *Corticium fuciforme* (Berk.) Wakefield | Cunningham 1954 |
| **Lupinus arboreus** Sims. | |
| *Stereum purpureum* Pers. | Cunningham 1957 |
| **Lycopersicum esculentum** Mill. | |
| *Diaporthe phaseolorum* (Cke. & Ell.) Sacc. | New Record |
| **Malva neglecta** Wallr. | |
| *Puccinia malvacearum Bert.* | Baker 1956 |
| **Malva parviflora** L. | |
| *Puccinia malvacearum* Bert. | Baker 1956 |
| **Medicago arabica** (L.) All. | |
| *Uromyces striatus* Schroet. | Additional Host Record |
| **Medicago hispida** Gaertn. | |
| *Uromyces striatus* Schroet. | Baker 1956 |
| **Medicago sativa** L. | |
| *Ascochyta imperfecta* Peck | Cunningham 1956 |
| **Mesembryanthemum australe** Sol. | |
| *Albugo mesembryanthemi* S. D. Baker | Baker 1955 |
| **Metrosideros excelsa** Sol. ex Gaertn. | |
| *Meliolina novae-zealandiae* Hansford | Hansford 1954 |
| **Myoporum acuminatum** R. Br. | |
| *Aecidium myopori* G. H. Cunn. | Additional Host Record |
| **Nerine curvifolia** Herb. var. **Fothergillii** Baker | |
| *Stagonospora curtisii* (Berk.) Sacc. | Dingley and Brien 1956 |
| **Nerium oleander** L. | |
| ~~*Pseudomonas savastanoi* (E. F. Smith)~~ Stevens | Dye, D. W. 1956 |
| **Nerine curvifolia** Herb. var. **fothergillii** Baker | |
| Leaf breakdown (physiological) | Thomson and Askew 1956 |
| **Nothofagus cliffortioides** Oerst. | |
| *Stereum purpureum* Pers. | Cunningham 1957 |
| **Phaseolus coccineus** L. | |
| *Uromyces appendiculatus* (Pers.) Link | Dingley and Brien 1956 |
| **Pinus radiata** D. Don. | |
| *Phytophthora cinnamomi* Rands | Hamilton 1956 |

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|---|---|
| **Pisum sativum** L. | |
| Marsh spot (physiological) | New Record |
| **Pittosporum tenuifolium** Banks & Sol. | |
| *Stereum purpureum* Pers. | Cunningham 1957 |
| **Poa anceps** Forst | |
| *Puccinia graminis* Pers. | Baker 1956 |
| **Prunus armeniaca** L. | |
| *Phytophthora syringae* Kleb. | Smith, H. C. 1956 |
| **Prunus avium** L. | |
| Cherry rasp-leaf virus | Helson 1953 |
| **Prunus persica** (L.) Batsch. | |
| *Physalospora obtusa* (Schw.) Cke. | Dingley and Brien 1956 |
| *Phytophthora cinnamomi* Rands. | Smith, H. C. 1956 |
| *Phytophthora syringae* Kleb. | Smith, H. C. 1956 |
| **Pyrus communis** L. | |
| *Elsinoe pyri* (Woronich) Jenkins | Brien and Dingley 1956 |
| **Pyrus malus** L. | |
| *Corticium salmonicolor* Berk. & Br. | New Record |
| *Leptosphaeria coniothyrium* (Fkl.) Sacc. | Additional Host Record |
| *Leptothyrium pomi* Sacc. | Dingley 1957 |
| **Rheum rhaponticum** L. | |
| *Pellicularia filamentosa* (Pat.) Rogers | Additional Host Record |
| **Rhododendron** sp. | |
| *Guignardia rhodorae* (Cke.) B. H. Davis | Dingley 1957 |
| *Pycnostysanus azaleae* (Peck) Mason | New Record |
| **Robinia pseudoacacia** L. | |
| *Stereum purpureum* Pers. | Cunningham 1957 |
| **Rosa** sp. cult. | |
| Rose-mosaic virus | Fry and Hunter 1956 |
| **Rubus idaeus** L. | |
| *Physalospora obtusa* (Schw.) Cke. | Dingley and Brien 1956 |
| **Scilla hispanica** Mill. | |
| *Uromyces scillarum* (Grev.) Wint. | Baker 1956 |
| **Senecio scorzoneroides** Hook. f. | |
| *Albugo tragopogi* S. F. Gray (Syn. *Cystopus cubicus* de Bary) | Baker 1955 |
| **Sisymbrium officinale** (L.) Scop. | |
| *Albugo cruciferarum* S. F. Gray (syn. *Cystopus candidus* (Pers. ex Chev.) Lev.) | Baker 1955 |
| **Soliva valdiviana** Phil. | |
| *Albugo tragopogi* S. F. Gray (syn. *Cystopus cubicus* de Bary) | Baker 1955 |
| **Taesonia mollissima** H.B.K. | |
| *Glomerella cingulata* (Stonem.) Sp. & Schr. | Additional Host Record |
| **Tagetes erecta** L. | |
| *Phytophthora cryptogea* Pethybr. & Laff. | Additional Host Record |
| **Tragopogon pratensis** L. | |
| *Albugo tragopogi* S. F. Gray (syn. *Cystopus cubicus* de Bary) | Additional Host Record |
| **Trifolium pratense** L. | |
| *Kabatiella caulivora* (Kirchn.) Karak. | New Record |
| **Trifolium repens** L. | |
| *Uromyces trifolii* (Hedw. f.) Lev. | Baker 1956 |
| **Triticum aestivum** L. | |
| *Pythium debaryanum* Hesse | Cunningham 1956 |
| **Ulex europaeus** L. | |
| *Stereum purpureum* Pers. | Cunningham 1957 |
| **Veronica tournefortii** Gmel. | |
| *Sorosphaera veronicae* Schroeter | Dingley and Brien 1956 |
| **Zea mays** L. | |
| *Nigrospora oryzae* (Berk. & Br.) Petch | Dingley 1957 |
| **Zinnia elegans** Jacq. | |
| *Alternaria zinniae* Pape | Dingley and Brien 1956 |

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